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Abstract:	Terrestrial fossil records from the SW Anatolian basins are crucial both for regional inter-basinal correlation and their palaeoenvironmental reconstruction. By reassessing biostratigraphic constraints and incorporating new fossil data, we calibrate and place the late Neogene and Quaternary palaeoenvironments within a regional palaeogeographic framework. Culmination of the Taurides in SW Anatolia was followed by a regional crustal extension from the late Tortonian onward that created a broad array of NE-trending orogen-top basins with a strongly synchronic basin-fill succession comprising alluvial-fan, fluvial and lacustrine deposits. The initial infill of these basins is documented by a transition from coarse-clastic alluvial fans and axial fluvial systems into central shallow-perennial lakes. The basal alluvial-fan deposits abound in fossil macro-mammals of an early Turolian (MN11-12; late Tortonian) age. The Pliocene period in the region was punctuated by more humid conditions resulting in a rise of local base-levels and expansion of lakes as evidenced by marsh-swamp deposits containing diverse fossil mammal assemblages indicating a late Ruscinian (late MN15; late Zanclean) age. A second pulse of extension, accompanied by regional climatic changes, prompted subsequent deepening of the lakes as documented by thick and laterally extensive carbonate successions. These lakes later shrank due to renewed progradation of alluvial-fans and eventually filled up and dried out, reflected by marsh-swamp deposits at the top of a complete lacustrine succession that contain a diverse micro-mammal assemblage indicating a latest Villanyian (MN17; Gelasian) age. A third pulse of extension dissected the basins into their present-day configuration from the late Pleistocene onward. The new age control provides adequate means to place the basin development in a regional tectonic framework which can be attributed to the consequence of well-articulated regional phenomenons of slab-tear induced uplift followed by crustal extension and basin formation (late Tortonian), the outward extension of the Aegean arc (middle Pliocene) and eventually accompanied by westward extrusion of the Anatolian plate (early Pleistocene).
Response to Reviewers:	The revised version includes all required changes. The Abstract has now been improved and more focused along the required changes. Terminological corrections from the Reviewer 1 is now carefully followed. Missed references are included. Redundant information and statements irrelevant to the topic are removed. Repetitions throughout the text have been eliminated. Mixing up of the descriptions and interpretations of the environmental interpretations, fossil determinations and geodynamics are now carefully eliminated. Along that determination and interpretation of the fossil data are separated, biostratigraphic data are clearly separated from the geodynamic interpretations. Introductive sentences removed from elsewhere of the paper and only restricted to the introduction chapter. The localities mentioned in the text are now indicated on the geological map. The basin descriptions separated from the fossil data. To have all biostratigraphic data traceable, two fossil figures of Fig. 2 and 3 are united into the Fig. 2. Moreover we did our own improvements as well.

Reconciling the stratigraphy and depositional history of the Lycian orogen-top basins, SW Anatolia

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Abstract

Terrestrial fossil records from the SW Anatolian basins are crucial both for regional inter-basinal correlation and their palaeoenvironmental reconstruction. By reassessing biostratigraphic constraints and incorporating new fossil data, we calibrate and place the late Neogene and Quaternary palaeoenvironments within a regional palaeogeographic framework.

Culmination of the Taurides in SW Anatolia was followed by a regional crustal extension from the late Tortonian onward that created a broad array of NE-trending orogen-top basins with a strongly synchronic basin-fill succession comprising alluvial-fan, fluvial and lacustrine deposits. The initial infill of these basins is documented by a transition from coarse-clastic alluvial fans and axial fluvial systems into central shallow-perennial lakes. The basal alluvial-fan deposits abound in fossil macro-mammals of an early Turolian (MN11-12; late Tortonian) age. The Pliocene period in the region was punctuated by more humid conditions resulting in a rise of local base-levels and expansion of lakes as evidenced by marsh-swamp deposits containing diverse fossil mammal assemblages indicating a late Ruscinian (late MN15; late Zanclean) age. A second pulse of extension, accompanied by regional climatic changes, prompted subsequent deepening of the lakes as documented by thick and laterally extensive carbonate successions. These lakes later shrank due to renewed progradation of alluvial-fans and eventually filled up and dried out, reflected by marsh-swamp deposits at the top of a complete lacustrine succession that contain a diverse micro-mammal assemblage indicating a latest Villanyian (MN17; Gelasian) age. A third pulse of extension dissected the basins into their present-day configuration from the late Pleistocene onward.

The new age control provides adequate means to place the basin development in a regional tectonic framework which can be attributed to the consequence of well-articulated regional phenomena of slab-tear induced uplift followed by crustal extension and basin formation (late Tortonian), the outward extension of the Aegean arc (middle Pliocene) and eventually accompanied by westward extrusion of the Anatolian plate (early Pleistocene).

Key words: Correlation, synchronicity, palaeoenvironments, mammal, post-orogeny, Taurides

Introduction

Collision and convergence of the microplates in the Eastern Mediterranean region, by the closure of Neotethys Ocean, resulted in the development of the Tauride Orogen during the Late Cretaceous to middle Miocene and is locally represented by the Lycian nappes in SW Anatolia (Şengör & Yılmaz 1981, Özgül 1976, 1984, Hayward & Robertson 1982, Robertson & Dixon 1984, Şengör et al. 1985, Zanchi et al. 1993, Collins & Robertson 1999, 2003, Ten Veen et al. 2009, Howell et al. 2017, Nemec et al. 2018). During the post-orogenic period, SW Anatolia was subsequently subjected to regional crustal extension, which led to the formation of a broad array of NE-trending extensional basins containing contemporary alluvial-fan, fluvial and lacustrine deposits. These post-orogenic basins were previously postulated as 'orogen-top rifts', which formed by multiple pulses of multi-directional crustal extension from the late Tortonian onward as documented by sedimentation pattern, biostratigraphy, geochronology, fault kinematics and morphotectonics (Becker-Platen 1970, Sickenberg & Tobien 1971, Sickenberg et al. 1975, Dumont et al. 1979, Angelier et al. 1981, Lefevre et al. 1983, Price 1989, Price & Scott 1989, Price & Scott 1991, 1994, Paton 1992, Alçiçek 2001, Saraç 2003, Cihat et al. 2003, Ten Veen 2004, Alçiçek et al. 2005, 2006, Westaway et al. 2005, Kaymakçı 2006, Koçyiğit & Deveci 2007, Alçiçek 2007, Platevoet et al. 2008, Alçiçek & Ten Veen 2008, Ten Veen et al. 2009, Karabacak 2011, Över et al. 2010, 2013a,b, 2016a,b, Alçiçek et al. 2013a,b, Van den Hoek Ostende et al. 2015a,b, Özsayın 2016, Elitez et al. 2017, Büyükmeriç 2017, Pickford 2016, Geraads 2017, Howell et al. 2017, Özkaptan et al. 2018, Kaymakçı et al. 2018).

The terrestrial fossil record from these basins, developed on the Taurides in SW Anatolia, is important for the understanding of regional inter-basinal correlation as well as for deconvolving basin spatio-temporal evolution of the basins. The sedimentary architecture combined with biostratigraphic evidence constrains the timing and evolutionary history of the region. In addition, the sedimentary record in these orogen-top basins provides vital information for understanding palaeoenvironmental changes during the last stages of orogeny, which can then be corroborated by faunal changes controlled by these environmental shifts. Documenting these environmental shifts is in turn important in recognising the role of Anatolia in faunal migration routes.

Some of these basins, such as the Çameli and Eşen, have been comprehensively studied, however, for others, the work is still in progress. In order to understand the tectonostratigraphic development of the basins in SW Anatolia, detailed biostratigraphic

information for dating the tectonic events in the region is essential. This need stimulates progress in further explorations and discovery of new fossil mammal sites to enhance the resolution of terrestrial Neogene stratigraphy in the region. The faunas from these localities are crucial for these terrestrial basins, as they provide invaluable data for understanding the stratigraphic, palaeoenvironmental and palaeogeographic evolution of the region (Alçiçek 2001). Furthermore, because it is located at the junction of Eurasia and Africa, Anatolia is in a unique position for the study of Neogene and Quaternary ecosystems, and for understanding key developments in the biogeography of western Eurasia. This includes the environmental shifts, interregional faunal exchanges including the dispersal of *Homo* through this region (Alçiçek 2010, Vialet et al. 2012, Alçiçek et al. 2017, Krijgsman et al. 2018).

The primary aim of this study is to fine-tune the stratigraphic framework, and to increase the resolution of timing of geodynamic events related to the deformation history of the eastern Mediterranean. This comparative study is a contribution towards a greater understanding of the development of an array of extensional basins on top of the Lycian nappes, and provides new insights into the tectonic history of the Taurides, with analogies drawn with other branches of the Alpine orogen.

Regional geological setting

The palaeo-Mediterranean region underwent diverse geodynamical processes linked to the syn-tectonic development of both perisutural (foreland) and episutural (thrust-top, back-arc) sedimentary basins, characterized by different subsidence rates and sedimentary processes (Cipollari et al. 1999). In SW Anatolia, the compression- and extension-related basins were developed as a consequence of the Tauride Orogeny associated with the overall convergence of the African-Eurasian plates during the Neogene to Quaternary (Sözbilir 2005, Alçiçek et al. 2005, 2006, Alçiçek 2007, Alçiçek & Ten Veen 2008, Ten Veen et al. 2009).

The western Taurides in SW Anatolia constitute the eastern extension of the Alpine orogeny and correlate with the Hellenides of Greece (Poisson 1984, Özgül & Arpat 1973, Bernoulli et al. 1974). They are subdivided into three main structural units: the Beydağları autochthon, Lycian nappes, and Antalya complex (Özgül 1976, 1984; Fig.1). On a regional scale, these structural units are attributed to different stages of the Neotethyan closure that involved the genesis and emplacement of large-scale carbonate platform units and ophiolitic nappes since the late Mesozoic times (de Graciansky 1972, Collins & Robertson 1997, 1998). The Beydağları autochthon forms a broad north-south trending anticlinorium underlying the

Lycian and Antalya nappes emplaced at its western and eastern flanks respectively, and contains Liassic to middle Miocene platform carbonates (Waldron 1981, Hayward & Robertson 1982, Collins & Robertson 1999). The Lycian nappes correspond to a segment of the orogenic-belt that originated in the northern Neotethys and comprise composite allochthonous thrust sheets transported from the Late Cretaceous to the middle Miocene and emplaced onto the Beydağları platform (Hayward & Robertson 1982, Robertson et al. 2003, Collins & Robertson 2003). The Antalya complex probably originated from the southern Neotethyan domain. It was emplaced on the eastern flank of the Beydağları platform by the Late Cretaceous-Neogene, and consists of allochthonous Mesozoic and older sedimentary, igneous and metamorphic rocks (Waldron 1981, Woodcock & Robertson 1982, Poisson et al. 2003, Koç et al. 2016).

The Lycian nappe stacks are covered, unconformably, by alluvial redbeds that are in turn overlain by Burdigalian shallow-marine reef limestones (Altınlı 1955, Becker-Platen 1970, Şenel et al. 1989, Hakyemez & Örçen 1982, Hakyemez 1989, Şenel 1997a, İslamoğlu et al. 2005, Alçiçek & Ten Veen 2008, Özcan et al. 2009, Akdeniz 2011a, b, Büyükmeriç 2017). Farther to the southeast, the nappe front is eventually overlain by Serravalian shallow marine clastics (Hayward 1984). The supra-allochthonous units are considered to be deposits of a piggy-back basin, transported jointly with the nappe progradation during the middle Miocene (Alçiçek & Ten Veen 2008, Ten Veen et al. 2009). The final movement of the nappes was followed by regional uplift corresponding to a non-depositional period that lasted c. 7 Myr (Alçiçek et al. 2018). This phase took place under NE-SW directed extension and resulted in an array of graben-type depressions stretched parallel to the transport direction of the nappe front and include Çal, Baklan, Acıgöl, Burdur, Çameli, Eşen and Beyağaç basins (Ten Veen 2004, Alçiçek et al. 2005, 2006, Alçiçek 2007, Ten Veen et al. 2009, Alçiçek et al. 2013). The tectono-sedimentary development of these basins is relatively uniform in the sense that all basins comprise a tripartite basin-fill that consists of an association of alluvial-fan, fluvial and lacustrine facies. Faunal evidence from the stratigraphic record of each basin indicates coeval terrestrial deposition through the early Turolian to the Gelasian.

Comparative basin stratigraphy

The first lithostratigraphical description and subdivision of SW Anatolian terrestrial successions was made by Becker-Platen (1970), who proposed a lithostratigraphic *Standard Profile* for regionally correlative, discernible sedimentary units comprising Yatağan and Milet

beds restricted to the Lycian hinterland. In this area sedimentation is represented by a coeval tripartite sequence ranging from alluvial-fan, fluvial and lacustrine deposits that laterally and vertically grade into each other. These units are collectively considered as 'neoautochthonous' and lithostratigraphically designated as the Çameli Formation by the Turkish Petroleum Corporation (TPAO) (Erakman et al. 1982a, b, Meşhur & Akpınar 1984, Erakman & Alkan 1986) and the Mineral Research and Exploration Directorate (MTA) (Şenel et al. 1989, Konak & Şenel 2002).

A first attempt at incorporating faunal evidence in order to strengthen both correlations and palaeoenvironmental reconstructions of the SW Anatolian basins was undertaken by Alçiçek (2010). Although that study was largely based on Saraç (2003), a scientific report with many preliminary identifications, it did manage to produce a general framework confirming the three pulses of crustal extension caused the basin formation as earlier proposed by Alçiçek (2001), Alçiçek et al. (2005) and Alçiçek (2007). Since then, palaeontological information on the area has increased tremendously. In addition to recent biostratigraphical studies (e.g., Van den Hoek Ostende et al. 2015a, b), newly discovered localities which are currently being studied, as well as literature on the faunal evidence (e.g. Saraç 2003) that previously had gone unnoticed, have contributed to a more accurate definition of the timing of the major changes in the sedimentation mode in the region and the accompanying environmental changes. As part of the work is still in progress, we can anticipate further advances in the reconstruction of the late Neogene and Quaternary history of SW Anatolia. On the other hand, only very few palynological investigations of this region and period have been published. Reasons for this are mainly the lack of palynomorph bearing sediments (e.g. oxidised or Ca-carbonate or gypsum rich sediments) and a very limited stratigraphical value of terrestrial palynomorphs for this period. For instance the appearance of *Fagus*, *Cedrus* and *Ilex* defined the latest Miocene and early Pliocne pollen zone ("Yeni Eskihisar Pollen Bild") of Benda (1971), while recent palynological investigations of the Yatağan Basin documented these taxa already for the middle Miocene (Bouchal in press, in this issue). Here, we synthesise existing palaeontological, sedimentological and various chronostratigraphic data with new observations on the pre-existing and new mammal fossil locations from the Lycian orogen-top basins (such as Çameli, Eşen, Beyağaç, Yatağan, Baklan, Acıgöl, Burdur) in SW Anatolia to (re)define the stratigraphic framework and constrain the timing of broad palaeo-environmental transitions in key Neogene basins of SW Anatolia.

The Çal Basin

The Çal Basin resides on the Lycian nappes and partly on the metamorphic Menderes Massif (Konak et al. 1986, Konak 2002). The basin succession unconformably overlies the bedrock and consists of two sequences which are separated by an angular unconformity. These sequences comprise sediments deposited in alluvial-fan, fluvial and palustrine environments. The alluvial-fan association constitutes the basal part of the basin-fill, which thickens towards the basin boundary faults and shows a basinward fining trend.

From the Asarlık locality, Kaya et al. (2008) and Alçiçek et al. (2012) reported Giraffidae (*Samotherium* sp., *Paleotragus* sp.), Bovidae (*Gazella* sp., *Palaeoreas* cf. *elegans*), Suidae (*Microstonyx* sp.), Chalicotheriidae (*Ancylotherium pentelici*) and Equidae (*Hipparion* sp.), indicating a middle Turolian age (MN12) (Table 1; Fig.2). The alluvial-fan deposits gradually pass upward into fluvial and palustrine facies associations that contain Pliocene freshwater molluscs *Bythinia, Dreissena* and ostracods *Cyprideis, Ilyocypris*, which are indicative of a standing body of water. The lower unit is unconformably overlain by alluvial floodplain deposits with a distinct palaeosol horizon at the top. This unit is restricted to the central part of the basin and forms an extensive plateau preserved as hanging terraces. The flood-plain deposits near Kırmızıtepe locality yielded Equidae (*Equus* sp.) and are considered to be of a Biharian age (Alçiçek et al. 2012*)* (Table 1; Fig.2).

The Burdur Basin

The Burdur Basin (Fig.1) resides on Mesozoic carbonate and ophiolite units of the Lycian nappes and Eocene–Oligocene supra-allocthonous sedimentary units (Şenel 1997a, 2002, Konak & Şenel 2002). The basin successions are composed of alluvial-fan to fluvial and shallow to deep lacustrine facies associated with volcanic intercalations (Karaman 1986, Price & Scott 1989, Alçiçek et al. 2013a, Demirel & Mayda 2014, Alçiçek et al. 2017a). Price (1989) reported some giraffid remains from the basal part of the basin-fill, representing the oldest fossil record reported in the basin (Fig.2). The morphology of the astragalus of this taxon is notably different from Plio-Pleistocene forms, suggesting a Turolian age for the specimen. Saraç (2003) also listed *Dipoides* sp., an extinct beaver genus from the Burdur-Akören-2 locality that belongs to the late Miocene/early Pliocene Anatolian faunas (MN12-MN14).

Recently, new macro-mammal remains were discovered in marsh/swamp deposits that stratigraphically lie in between the fluvial and lacustrine deposits of the basin succession. The

micro- and macro-mammal fossil content from the Sultandere locality (Fig.1) revealed a diverse fauna implying a wide variety of habitats were present during the early/middle Pliocene (MN14/15, Ruscinian). Among the fossil mammals, the medium-sized deer *Croizetoceros* (Mayda et al. 2017) and the antelope *Gazellospira* are typical of the Plio-Pleistocene taxa, whereas the primitive gerbil genus *Pseudomeriones* has its latest representative in the late Pliocene (MN15) locality of Çalta, Turkey (Şen 1977, 1998, Sylvestrou & Kostopoulos 2007) (Fig.2). A recent magnetostratigraphic study (Özkaptan et al. 2018) assigns 5.0-4.5 Ma age for the base of the lacustrine succession of the Burdur. This age determination calibrates our recent finding of MN15 biota in the Sultandere locality underlying the lacustrine succession of the Burdur basin (Table 1).

The uppermost reach of the basin succession, which consists of fluvio-deltaic deposits, yielded a Villanyian (MN17) fauna from the localities of Elmacık, Yassıgüme and Kocakır (Alçiçek et al. 2013b, Alpagut et al. 2015, Demirel & Mayda 2014, Demirel et al. 2016, 2017; Table 1, Fig.2) aligned along the SE-margin of the basin. The Elmacık locality contains Proboscidea (*Mammuthus meridionalis*, Elephantidae indet.), Equidae (*Equus stenonis*/*altidens*, *Equus* sp.), Rhinocerotidae (*Stephanorhinus* cf. *etruscus*), Bovidae (*Gazellospira torticornis*, *Leptobos etruscus*, *Eobison* sp., Bovidae indet.), Cervidae (*Eucladoceros* sp., Cervidae indet.), Testudinidae (*Testudo* sp.) and avian remains (Alpagut et al. 2015). The Yassıgüme locality (Demirel & Mayda 2014) contains *Leptobos* cf. *etruscus*, *Gazellospira torticornis* and *Equus* sp. indicating a late Villafranchian association, which was typical for western and southeastern European taxa. This assemblage suggests an early late Villafranchain (~1.5 Ma) age of the uppermost part of the basin succession. The new locality of Yassıgüme provided two differently-sized bovids and *Equus*. Pleistocene fossil bovid remains from Turkey are rare. The Yassigüme bovine *Leptobos etruscus* is the first occurrence of this species in Anatolia, expanding the known range of the species.

The Kocakır-1 locality contains *Equus sp.* and *Paracamelus gigas* (Alçiçek et al. 2013b). Kocakır-2 is stratigraphically comparable but is much richer in species than Kocakır-1. The tentative results of the initial survey of Kocakır-2 showed the presence of two equids of different size (*Equus* cf. *altidens* and *Equus suessenbornensis)*, a small rhino (*Stephanorhinus* cf. *hundsheimensis*), a giant camel (*Paracamelus gigas*), a panther (the size of *P. gombaszoegensis*), a wolf like dog (*Canis arnensis*), a hippo (*Hippopotamus* sp.) and a medium-sized bovid (Bovidae indet.) (Table 1). Overall, this fairly diverse fauna reflects an open habitat with a limited number of water bodies. The combination of *Paracamelus*, *Equus*

and a medium-sized deer is typical for the middle-late Villafranchian associations of eastern Europe and western and central Asia (Alçiçek et al. 2013, Kalhke et al. 2011).

Further to the south, a locality near the village of Hasanpaşa is situated in the uppermost part of the lacustrine unit. This site yielded *Mammuthus meridionalis* and *Gazella* sp., indicating a late Pliocene-early Pleistocene age interval of 3.0-2.0 Ma (MN17; middle Villanyian, Sickenberg et al. 1975, Saraç 2003). A recent magnetostratigraphic study indicates 2.5 Ma for the top of the succession (Özkaptan et al. 2018). This age determination calibrates MN17 biota from the Kocakır-1 (Alçiçek et al. 2013) and Kocakır-2 and Yassıgüme localities (Demirel & Mayda 2014) overlying the lacustrine succession of the Burdur basin (Table 1).

In the Gölcük volcanic province, c. 20 km to the NE of the basin, the basin succession interfingers with volcaniclastics of 4.77±0.25 to 4.07±0.20 Ma in age (Lefevre et al. 1983). Price (1989) undertook K-Ar dating from tephra at the centrally placed Gölcük Maar, which provided an age of 4.6±0.2 Ma. The volcanic intrusions and lava flows overlie Miocene deposits and interfinger with the basin-fill. The middle parts of the volcanics were assumed to be of late Pliocene age based on the tephra interlayers of that age in the adjacent Burdur graben. By using K-Ar age determination from tephra interlayers Nemec et al. (1998) showed that explosive activity of the Gölcük volcano continued until early Pleistocene time with the youngest activity in historical times at 1.50±0.18 and 1.38±0.13 Ka ago.

The Baklan Basin

The Baklan Basin developed on the Mesozoic sequence of the Lycian nappes (Sözbilir 2005, Konak & Şenel 2002, Alçiçek et al. 2013a; Fig.1). The basin-fill consists of alluvial-fan to fluvial and lacustrine deposits. The base of sequence was dated as early Turolian based on large mammal fossils from the Mahmutgazi locality (Sickenberg & Tobien 1971, Sickenberg et al. 1975, Pickford 2016, Geraads 2017). The locality includes three main fossil localities, which comprise a faunal assemblage including following species; *Adcrocuta eximia, Protictitherium crassum, Machairodus aphanistus, Indarctos atticus, Chilotherium schlosseri, Diceros neumayri, Ancylotherium pentelicum, Cremohipparion matthewi, Palaeoryx pallasi, Plesiaddax inundates, Tragoportax amalthea, Samotherium major, Hippopotamodon erymanthius, Orycteropus* sp., and *Choerolophodon pentelici*. This diverse fauna resembles the late Miocene assemblage from the Greco-Iranian bioprovince and this locality can be assigned to the late MN11 biozone (Table 1; Fig.2). Higher up in the succession, in the fluvio-deltaic deposits, a *Pseudomeriones tchaltaensis* reported by Wesselingh & Alçiçek (2010)

suggests a Ruscinian (MN15) age. Even higher up, a *Microtus* sp. found during this study indicates an Biharian age.

The Acıgöl Basin

The Acıgöl Basin resides on Mesozoic basement composed of allochthonous rocks of limestones and ophiolitic rocks of the Lycian Nappes, and overlying Oligocene marine to continental sediments (Konak et al. 1986, Şenel 1997, Konak & Şenel 2002, Turan 2002, Sözbilir 2005; Fig.1). The basin strikes NE-SW and is developed within an eastward-tilted tectonic depression in which upper Miocene coarse-grained terrestrial sediments were initially deposited (Göktaş et al. 1989, Alçiçek 2009, Helvacı et al. 2013, Alçiçek et al. 2013a). From the Zanclean to Gelasian, a progressive deepening of the basin provided accommodation space for the deposition of lacustrine units, which unconformably overlie the pre-Neogene basement rocks. The only fossil mammal material from the basin was discovered by MCA in the alluvial-fan deposits of the uppermost reach of the Acıgöl basin-fill and represents a typical late Pleistocene element in the form of *Equus hydruntinus* (Alçiçek et al. 2013b).

The Çameli Basin

The Çameli Basin resides on the Lycian nappes and constitutes NE-trending inter connected tilt-block compartments associated with NW-dipping secondary normal faults (Fig.1). The basin-fill was designated as the Çameli Formation by Erakman et al. (1982a, b) and Erakman & Alkan (1986), and comprises alluvial-fan, fluvial and lacustrine deposits. Progressive angular unconformities are present within the proximal facies along the basin margins. The alluvial-fan deposits occur in the lower and upper parts of the basin-fill along the basin margin and grade laterally and vertically into the fluvial deposits. The fluvial deposits also grade laterally and vertically into lacustrine facies that are restricted to the central and upper part of the sequence. In the basin center, these tripartite deposits grade into each other and reach up to 500 m in thickness. The age of the basin-fill is determined to be Turolian to Villanyian based on mammal fauna and radiometric dating (Şenel 1997a,b,c, Saraç 2003, Alçiçek et al. 2005, Van den Hoek Ostende et al. 2015a,b, Elitez et al. 2017). The biostratigraphical studies by Van den Hoek Ostende et al. (2015a, b) have contributed to accurate definition of the exact timing of major changes in the basin's sedimentation mode.

The vertebrate fauna of coal-bearing deposits in the Elmalıyurt (Pırnaz) locality on the SE margin of the basin contains an upper dentition of a medium-sized hipparionine (Saraç 2003;

Table 1). This mammal specimen was preliminarily identified by Saraç (2003) as the Vallesian species *Hippotherium primigenium,* and this identification was reiterated by other workers (Alçiçek 2001, Alçiçek et al. 2005). The characteristics of the *H. primigenium* group as defined by Bernor et al. (1996) are complex pre- and post-fossette enamel plications; maintaining deeply amplified plis, and an incised hypoglyph accompanying the lingually flattened, labially rounded and more lingually placed protocone. Comparing the mean protoconal length and the plication count, the Elmalıyurt specimen differs from those of *H. primigenium* from Höweneg (MN9-Vallesian), and Eppelsheim (MN9-10; Vallesian) by having a moderate enamel plication (15-20 plicae) with short-narrow plis, oval, relatively small protocone (6-8 mm) free from protoloph with weak and asymmetrical double pli caballin. Instead, the medium-sized Elmalıyurt hipparion is comparable with the Turolian forms of Bulgaria and Greece, especially those from the Anatolian faunas of Sivas-Düzyayla (MN11, early Turolian, Kaya & Forsten 1999), Uşak-Kemiklitepe A-B (MN11-12, early-middle Turolian, Koufos & Kostopoulos 1994), Muğla-Şerefköy (MN12; early Turolian, Kaya et al. 2012) and Özlüce (MN11, early Turolian, Alpagut et al. 2014). In particular, *H. mediterraneum,* which is well-represented from middle Turolian (MN 12) localities from Greece (Pikermi and Perivolaki), Bulgaria (Kalimantsi and Hadjidimovo) and Turkey (Kemiklitepe A-B and Düzyayla, closely resembles the Elmalıyurt hipparion in size and morphology. In view of the existing material, we classify the Elmalıyurt specimen as *Hipparion* cf. *mediterraneum*, noting that it certainly does not represent *H. primigenium*, but rather resembles Turolian forms, especially *H. mediterraneum.* Consequently, the Elmalıyurt locality in the lowermost part of the Çameli basin succession is considered to be Turolian in age.

The lacustrine unit in the basin is confined by coal-bearing marsh-swamp deposits at the bottom and top. At the base, the Ericek locality contains murines (*Apodemus* cf. *dominans*, *Rhagapodemus* cf. *primaevus*, *Orientalomys* cf. *similis*), arvicoline (*Mimomys occitanus*), cricetine (*Cricetulus*), glirid (*Muscardinus*), and shrew (*Asoriculus* sp.), which were assigned to late MN15, i.e., late Ruscinian (Van den Hoek Ostende et al. 2015a, Table 1; Fig.2). Higher in the section, the unit grades from a shallow to deep lake environment. The mollusc content, with *Paludina, Lymnaea, Radix, Lithoglyphus, Pyrgula* (Becker-Platen 1970), *Melanopsis, Pseudamnicola* (Alçiçek et al. 2005) and ostracods of *Cyprideis pannonica*, *Candona parallela pannonica, Heterocypris salina, Ilyocypris* sp., *Eucypris* sp. (Darbaş 2017), marks the transition from shallow to deeper lake environments. The uppermost part of the succession grades again into coal-bearing marsh-swamp deposits abounding in mammal remains

including cricetines, arvicolines and murines, similar to the locality of Bıçakçı (MN17, late Villanyian; Alçiçek et al. 2005, Van den Hoek Ostende et al. 2015b; Table 1; Fig.2).

The Eşen Basin

The Eşen Basin, a NE-trending extensional graben, resides on the hinterland ramp-fold near the Lycian nappe front (Alçiçek 2007; Fig.1). This terrestrial basin is highly comparable with the adjacent Çameli basin from which fossil mammals allow reliable time-stratigraphic comparisons with recognized extensional pulses (Alçiçek et al. 2005). The early basin-fill was described as comprising alluvial-fan deposits including *Palaeotragus rouneii* (Artiodactyla, Giraffidae) (MN9-12, Vallesian-middle Turolian, Karamusalar locality, Alçiçek 2007), and an ostracod fauna of *Hemicythere*, *Candona*, *Eucypris*, *Cyprideis* and *Pontocypris* (Becker-Platen 1970). In this study, new large mammal remains have been unearthed from the same locality reported by Alçiçek (2007). The newly collected fauna contains a small-sized bovid (*Gazella* sp.), cervid (Cervidae indet.), equid (*Hipparion* sp.) and a small-sized giraffid (*Palaeotragus* sp.), constraining the age to Turolian (MN11-12; Table 1, Fig. 2).

The alluvial-fan deposits grade upward into fluvial and eventually shallow lacustrine deposits. Initial lacustrine deposition is represented by marsh-swamps comprising freshwater ostracods and mollusks including *Miocyprideis*, *Limnocythere*, *Candona*, *Pisidium*, *Ilyocypris*, *Cypridopsis*, *Cyprideis*, *Adelina*, *Corymbina*, *Paludina*, *Unio* and *Bulimus* (Colin 1962, Becker-Platen 1970) and Cyprinodei remains of *Onychoden*, *Mitraden* and *Tinca* (Alçiçek 2007). The *Corymbina* gastropod species are very similar to those found in the Apolakkia Formation of SE Rhodos with middle-late Ruscinian age (MN15; lower-middle Pliocene; Van de Weerd et al. 1982). Upward the lacustrine deposits abound in mollusc, ostracod and fish assemblages representing deeper lake environment (Table 1). Later, the deep lacustrine basin eventually shrank and was filled in owing to renewed progradation of alluvial-fan and fan-deltaic deposits derived from the basin margins.

The Beyağaç (Barz) Basin

The Beyağaç basin was first described by Becker-Platen (1970; Barz Plain in there) and its geological map has recently been compiled by Akdeniz (2011a; Fig.3). The basin contains two distinct sedimentary units; the Yatağan beds at the base, comprising alluvial-fan and fluvial deposits, and the Milet beds with lacustrine sediments at the top.

The basal Yatağan unit consists of alluvial-fan and fluvial deposits which thicken towards the basin boundary faults and show basinward thinning and fining trends. The Sazak locality, at the western basin margin, yielded fossils of *Hipparion matthewi*, *Ceratotherium neumayri*, *Helladotherium duvernoyi*, *Protoryx carolinae*, *Tragoportax amalthea*, *Gazella deperdita* and *Adcrocuta eximia,* indicating a middle Turolian age (MN12; Schmidt-Kittler 1976, Kaya 1993, Tuna 1999, Koufos et al. 2018). The new Kozlar locality at the eastern basin margin was discovered during this study and is still under investigation, but revealed equid (*Hipparion*) and rhinocero (*Ceratotherium*) material suggesting a middle Turolian age (MN12, Table 1; Fig.2). Higher up in the seqeuence, the alluvial-fan deposits gradually pass upward into the fluvial facies association and are eventually overlain by the lacustrine Milet unit with a coal seam at the bottom. The basin-fill is unconformably overlain by younger alluvial-fan deposits.

Discussion

Regional crustal extension following the culmination of the Tauride orogeny gave rise to the development of several terrestrial basins in SW Anatolia (Şengör & Yılmaz 1981, Robertson & Dixon 1984, Şengör et al. 1985, Zanchi et al. 1993, Ten Veen et al. 2009). A combination of detailed bio- and lithostratigraphy of the basin fills underpins a well-constrained model for the basin evolution that is used here as a solid time-stratigraphic framework enabling the improved timing of tectonic events along the Lycian hinterland.

The final nappe-related sedimentation in the region occurred during the early Miocene in piggy-back basins composed of terrestrial deposits, which were subsequently drowned by a Burdigalian transgression. This marine transgression was followed by regional uplift that led to local extension and formation of a NE-trending array of normal-fault bounded graben type basins. The reef unit presently stands at maximally 1846 m attributed to the gravitationally isostatic (orogenic) rebound of the nappe stack (Alçiçek & Ten Veen 2008). A 7 my period of non-deposition was followed by terrestrial sedimentation during the late Tortonian that dominated the extensional basins in the Lycian hinterland. The non-deposition period corresponded with a shift from compression to extension (Alçiçek et al. 2018).

On the Taurides in the SW Anatolia, Alçiçek (2001) attempted to obtain stratigraphic resolution that would enable an accurate definition for the duration of tectonic phases related to crustal deformation. Following that approach, Alçiçek et al. (2005) and Alçiçek (2007) described terrestrial orogen-top basins such as Çameli and Eşen and distinguished three

distinct pulses of crustal extension that occurred in the late Miocene, middle Pliocene and early Pleistocene times, respectively. Spatial and temporal correlation of the facies associations in each individual basin indicate that they are correlative and deposited coevally with typical tripartite facies associations; alluvial-fan facies at the margin, fluvial and lacustrine facies in the centre.

The post-orogenic terrestrial basins collectively provide sedimentary and stratigraphic data describing synchronicity of the individual basin development and related sedimentation as well as describing interconnections between the tectonic provinces. The new age control presented here provides the means to place the basin development in the well-articulated regional tectonic framework (Ten Veen 2004, Alçiçek et al. 2006, Ten Veen et al. 2009). Late Neogene and Quaternary neotectonic developments in western Anatolia are characterized by extensional crustal deformation that resulted in the development of fault-bounded basins. This extension has strongly influenced the basin configuration, changed the sedimentation mode and given rise to several graben-type basins such as Çal, Baklan, Acıgöl, Burdur, Çameli, Eşen and Beyağaç. These basins, related to post-orogenic processes, were formerly presented as multiply pulsed orogen-top basins (Alçiçek 2001, Purvis & Robertson 2004, Alçiçek et al. 2005, Alçiçek 2007). Here, we synthesise the available data to develop a unified three phase model for basin sedimentation across the SW Anatolian region.

Phase I – Basin formation (late Tortonian)

The basal alluvial flood plain deposits of the SW Anatolian basins abound in large fossil mammal remains including the localities of Mahmutgazi in Baklan, Asarlık in Çal, Elmalıyurt (Pırnaz) in Çameli, Karamusalar in Eşen, Şerefköy in Yatağan, Sazak and Kozlar in Beyağaç, Kemer in Burdur basins (Table 1, Fig.2). The fossils found in these localities are typical of the so-called Greco-Iranian or sub-Paratethyan province, also known as the Pikermi biome (Geraads 2017, Kaya et al. 2012, Pickford 2016). This assemblage is suggestive of open forested landscapes ranging from sclerophylous evergreen to mixed conifer and deciduous woodlands to open xerophyic terrains forming a mosaic of different plant associations (Jiménez-Moreno et al. 2007, Biltekin et al. 2015) and indicating relatively humid climatic conditions in the late Tortonian. Around 5.9 Ma (late Turolian), an onset of drastic climatic change with greater aridity and continentality and cooler climate occurred in the eastern Mediterranean in combination with the continued convergence between Africa and Europe. This led to easier and more rapid faunal exchanges between the two continents. However,

only a sparse record of large grazing mammals, living in open areas, is found in the late Turolian. These taxa adapted to more dry and open environments. Climate became more arid at the end of the late Miocene, resulting in more open vegetation and more rare forest vegetation (Biltekin et al. 2015).

All of the fossil localities observed in the lowermost stratigraphy of each basin have a similar age range of early-middle Turolian (MN11-12). Therefore, it appears that the SW Anatolian post-orogenic basins subsided synchronously and initially filled with alluvial-fan deposits in a high-energy setting. During the basin subsidence, the marginal alluvial-fans from the basin-bounded escarpments supplied rivers running along the basin axis and accompanied by ephemeral lakes in the basin center. The basins were underfilled, represented by the rate of potential accommodation exceeding rate of sediment/water supply, gradually filling with a fining-upward fluvial sequence in which braided streams predominated, punctuated by sheet-floods and graded into meandering systems (Caroll & Boharcs 1999). Eventually these fluvial systems were gradually drowned by shallow-lacustrine marsh-swamp environments.

Phase II – Lacustrine period (early Pliocene)

The initial basin-fill composed of alluvial-fan and fluvial deposits was subsequently drowned by extensive lakes by the early Pliocene. These initial lacustrine deposits are marked by shallow-lacustrine facies assemblages of marsh-swamp environment, which abound in fossil micro-mammals and amphibians. These conditions are most common in balanced-fill lake, characterized by the rates of sediment/water supply in balance with potential accommodation (Carroll & Bohacs 1999). The timing of the lacustrine inundation has been well established by microvertebrate remains from the locality of Ericek in the Çameli basin (Alçiçek 2001, Alçiçek et al. 2005, Van den Hoek Ostende et al. 2015a). At the lowermost part of the lacustrine succession, cypriniform fish assemblages were reported by Rutte & Becker-Platen (1980) in the Baklan basin and Alçiçek (2007) found similar cypriniform assemblages in the Eşen basin. New fossil mammals yielded from the Sultandere locality of Burdur and the Afşar locality of Sandıklı are of Ruscinian age, supporting the lacustrine inundation throughout SW Anatolia and also implying humid climatic conditions at that time, given, for instance, the high proportion of desmanine moles in the locality of Afşar (Table 1, Fig.2). A similar fossil mammal reported by Saraç (2003) from the Bozarmut locality in the Yatağan basin extends the lacustrine inundation further to the west. The Mio-Pliocene boundary saw a major faunal turnover in the Mediterranean mammal faunas, which in the east

marks the end of the Pikermian biome (Eronen et al. 2009). In SW Anatolia, this turnover is marked by the presence of various wood mice and a palaeobatrachid frog in the Ericek locality of the Çameli basin (Van den Hoek Ostende et al. 2015b).

Initial shallow lacustrine basins gradually deepened as marked by thick, homogeneous marly carbonate deposits. The deep lacustrine deposits are concentrated to the centres of the basins, and locally overlap the basin margins implying a lacustrine inundation following renewed basin subsidence possibly owing to renewed extension. Eventually the individual lakes were united to constitute a single mega-lake in SW Anatolia during the Pliocene (Spratt & Forbes 1847, Becker-Platen 1970, Luttig & Steffens 1976, Görür et al. 1995, 1998). Such a palaeo-lake environment was envisaged by Bering (1971) as the Pisidic Lake. Pamir (1974) has further extended this connection up the Denizli basin to the north on the basis of the presence of *Cardium* assemblages.

Phase III – Basin dissection (early Pleistocene)

The adjoined lake basins gradually and synchronously shrank by the early Pleistocene as indicated by a gradual transition of homogeneous lacustrine marls into shallow lacustrine marsh-swamp deposits. The shallow lacustrine environments abound in fossil micro- and macro-mammal assemblages across the entirety of SW Anatolia. Locations include the Bıçakçı locality in Çameli, Kırmızıtepe locality in Çal, Gelinören locality in Baklan, Yelalan locality in Acıgöl and Kocakır, Elmacık, Yassıgüme and Ardıçtekke localities in Burdur basins (Alçiçek 2001, Alçiçek et al. 2005, Wesseling & Alçiçek 2010, Alçiçek et al. 2012, 2013a, Demirel & Mayda 2014, Van den Hoek Ostende et al. 2015a, b, Alçiçek et al. 2017). The more open vegetation conditions are well-reflected in the Bıçakçı fauna at the demise of the lacustrine period with subhumid climatic conditions. That fauna is dominated by hamsters (cricitines), and shows in addition a large variety of voles (microtines). Murids, which were dominant in the preceding period, now play a far more modest role (Van den Hoek Ostende et al. 2015a, Alçiçek et al. 2017).

During the early Pleistocene, a renewed pulse of extension prompted the deposition of coarse-grained alluvial-fan sediments derived from the basin margins interfingering with the lacustrine sediments towards the basin centre. In this stage, the lake accommodation space was eventually exhausted, as is indicated by the basin-wide expansion of alluvial to fluvial sedimentation. This stage was attributed to a change in the direction of extension that is considered to have affected the entire area of SW Anatolia (Ten Veen 2004, Alçiçek et al.

2006, Ten Veen et al. 2009). During this phase, the mega-basin became totally dissected. Lower Pleistocene coarse clastic alluvial-fan deposits that unconformably overlie older Neogene units in SW Anatolia exemplify the renewed extension. This alluvial unit has a distinct dark-red colour with prominent pedogenic horizons in the over-bank deposits. The succeeding (i.e., Holocene) period is characterized predominantly by degradation of topographic highs through deeply incising river erosion. Newly generated faults as well as reactivated faults are thought to have been associated with subduction roll-back extension, which further enhanced the basin-and-range topography of SW Turkey (Alçiçek et al. 2005, Alçiçek 2007, Ten Veen et al. 2009).

Conclusions

The sedimentary architecture of SW Anatolian terrestrial basins has been linked to multiple pulses of extension that are reflected in palaeoenvironmental changes. Strongly concerted environmental changes in the basins are based on their integrated faunal- and depositional assemblages. Stratigraphy and sedimentation patterns of the mammal bearing strata in this Lycian orogen-top domain allows us to present a regional inter-basinal correlation and palaeobiogeographical reconstruction over the Anatolian gateway, which is uniquely located along the migration route critical to the fauna of the Old World. Biostratigraphic constraints in these basins have been reassesed with the support of new fossil finds to calibrate and age-constrain the palaeoenvironments within a regional palaeogeographic framework. The fossil associations have been combined with the sedimentation pattern to refine the post-orogenic basin development and regional palaeobiogeography throughout the Lycian Taurides. Our studies have reaffirmed the triparte nature of the sedimentation in the various basins, which is synchronous and represents a late Miocene, Pliocene and early Pleistocene phase, each with its own particular environments.

Terrestrial sedimentation on the Lycian hinterland had commenced by the late Tortonian (early Turolian) following c. 7 my of non-deposition following the latest marine transgression in the region. In the early stage, the basins subsided to form a transition from coarse-clastic alluvial-fans and axial fluvial systems. These alluvial flood-plain deposits abound in large mammal taxa of the Pikermi biome, implying an open, seasonal palaeoenvironment with grass-dominated steppe ecosystem. The terrestrial fossil assemblages correlate with those of adjacent basins indicating palaeobigeographical connections.

By the early Pliocene (late Ruscinian), gradual transition from an alluvial-fan environment into a fluvial system was initiated by regional climatic variations changing into warm and more humid conditions with savannah-type open habitats, resulting in base-level rise, lake expansion, ascending river gradient and increased flow-capacity. The humidity was sustained until the late Pliocene, when shallow-palustrine lacustrine environments comparable with the modern SW Anatolian lacustrine basins appeared. The fossil associations underlying and overlying the Pliocene lacustrine deposits indicate the duration of the lake phase of at least 1 ma.

By the early Pleistocene (latest Villanyian), the basin was dissected by newly generated faults and the the basin configuration was re-arranged. The base-level changes resulted in coarse-clastic alluvial-fan to fluvial material unconformably overlying the earlier deposits in the basins. This unit contains large mammal taxa representing an open steppe ecosystem under more temparate (i.e. semiarid) climatic conditions.

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References

Akdeniz, N. (2011a). Geological maps of Turkey in 1:100.000 scale: Denizli N21 sheet. *Mineral Research and Exploration Directorate of Turkey*, Ankara, 41 pp.

Akdeniz, N. (2011b). Geological maps of Turkey in 1:100.000 scale: Denizli N22 sheet. *Mineral Research and Exploration Directorate of Turkey*, Ankara, 44 pp.

Alçiçek, H. (2009). Late Miocene nonmarine sedimentation and formation of magnesites in the Acıgöl Basin, southwestern Anatolia, Turkey. *Sedimentary Geology*, 219, 115-135.

Alçiçek, H. (2010). Stratigraphic correlation of the Neogene basins in southwestern Anatolia: regional palaeogeographical, palaeoclimatic and tectonic implications. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 291, 297-318.

Alçiçek, H., Alçiçek, M.C. (2014). Palustrine carbonates and pedogenic calcretes in the Çal basin of SW Anatolia: Implication on the Plio-Pleistocene regional climatic pattern in the eastern Mediterranean. *Catena*, 112, 48-55.

Alçiçek, H., Wesselingh, F.P., Alçiçek, M.C., Jiménez-Moreno, G., Feijen, F.J., Hoek Ostende, L.W. van den., Mayda, S., Tesakov, A.S. (2017a). A multiproxy study of the early Pleistocene palaeoenvironmental and palaeoclimatic conditions of an anastomosed fluvial sequence from the Çameli Basin (SW Anatolia, Turkey). *Palaeogeography, Palaeoclimatology, Palaeoecology*, 467, 232-252.

Alçiçek, M.C. (2001). Sedimentological investigation of the Çameli Basin (Late Miocene-Late Pliocene, Denizli, SW Anatolia). *Unpubl. Ph. D. Thesis*, Ankara University, pp.101.

Alçiçek, M.C. (2007). Tectonic development of an orogen-top rift recorded by its terrestrial sedimentation pattern: the Neogene Eşen Basin of southwestern Anatolia, Turkey. *Sedimentary Geology,* 200, 117-140.

Alçiçek, M.C. (2015). Comment on "Tectonophysics 635, 80-99 by J. Hall, A.E. Aksu, İ. Elitez, C. Yaltırak, G. Çiftçi" *Tectonophysics*, 664, 1-4.

Alçiçek, M.C., Brogi, A., Capezzuoli, E., Liotta, D., Meccheri, M. (2013a). Superimposed basin formation during Neogene–Quaternary extension in SW-Anatolia (Turkey): Insights from the kinematics of the Dinar fault zone. *Tectonophysics*, 608, 713-727.

Alçiçek, M.C., Hoek Ostende, L.W. van den., Saraç, G., Tesakov, A.S., Murray, A.M., Hakyemez, H.Y., Göktaş, F., Mayda, S., Jiménez-Moreno, G., Büyükmeriç, Y., Wesselingh, F.P., Alçiçek, H. (2018). Comment on "Tectonophysics 690, 336-354*." Tectonophysics*, 722, 595-600.

Alçiçek, M.C., Kazancı, N., Özkul, M. (2005). Multiple rifting pulses and sedimentation pattern in the Çameli Basin, southwestern Anatolia, Turkey. *Sedimentary Geology*, 173, 409-431.

Alçiçek, M.C., Mayda, S., Alçiçek., H. (2012). Faunal and palaeoenvironmental changes in the Çal Basin, SW Anatolia: Implications for regional stratigraphic correlation of late Cenozoic basins. *Comptes Rendus Geoscience,* 344, 89-98.

Alçiçek, M.C., Mayda, S., Demirel, A. (2017b). Discussion on "Neogene-Quaternary evolution of the Tefenni basin on the Fethiye-Burdur fault zone, SW Anatolia-Turkey. Journal of African Earth Science 118, 137-148 by R. Aksoy, S. Aksarı" *Journal of African Earth Science,* doi:10.1016/j.jafrears.

Alçiçek, M.C., Mayda, S., Titov, V.V. (2013b.) Lower Pleistocene stratigraphy of the Burdur Basin of SW Anatolia. *Comptes Rendus Palevol,* 12, 1-11.

Alçiçek, M.C., Ten Veen, J.H. (2008). The late Early Miocene Acipayam piggy-back basin: refining the last stages of Lycian nappe emplacement in SW Turkey. *Sedimentary Geology,* 208, 101-113.

Alçiçek, M.C., Ten Veen, J.H., Özkul, M. (2006). Neotectonic development of the Çameli Basin, southwestern Anatolia, Turkey. In: Robertson, A.H.F., Mountrakis, D. (Eds.), Tectonic Development of the Eastern Mediterranean Region. *Geological Society London Special Publication*, 260, 591-611.

Alpagut, B., Kaya,T.T., Mayda,S., Demirel, A., Ekinci, H.A. (2015). Burdur-Elmacik Fossil Vertebrate Locality. *68th Geological Congress of Turkey*, 06-10 April 2015 Ankara. Abstracts, 498-499 p.

Alpagut, B., Mayda, S., Kaya, T., Göktas, F., Halaclar, K., Kesici, S.D. (2014). Overview of Recent Research on Muğla-Özlüce Mammalian Fossil Locality. *67th Geological Congress of Turkey*.15-18 April 2014-Ankara, 732-733.

Altınlı, İ.E. (1955). The geology of southern Denizli. Revue de la Faculté des Sciences de I'Université d'Istanbul, Serie B: *Sciences Naturelles*, 20 (1-2), 1-47.

Angelier, J., Dumont, J.F., Karamanderesi, İ.H., Poisson, A., Şimşek, Ş., Uysal, Ş. (1981). Analyses of fault mechanism and expansion of southwestern Anatolia since Late Miocene. *Tectonophysics,* 75, T1–T9.

Atalay, Z. (1980). Stratigraphy of continental Neogene in the region of Muğla-Yatağan, Turkey. *Bull. Geol. Soc. Turkey*, 23, 93–99.

Athanassas, C.D., Modis, K., Alçiçek, M.C., Theodorakopoulou, K. (2018). Contouring the cataclysm: a geographical analysis of the effects of the Minoan eruption. *Environmental Archaeology* doi: 10.1080/14614103.2017.1288885.

Becker-Platen, J.D. (1970). Lithostratigraphisce Untersuchungen im Kanozoikum Südwest-Anatoliens (Türkei). *Beihefte zum geologischen Jahrbuch,* 97.

Benda, L. (1971). Principles of the palynologic subdivision of the Turkish Neogene.*Newsletters on Stratigraphy*, 1-3, 23-26.

Bering, D. (1971). The development of the Neogene and Quaternary intramontane basins within the Pisidic lake district in S. Anatolia. *Newsletters on Stratigraphy*, 1, 27-32.

Bernor, R.L., Koufos, G.D., Woodburne, M.O., Fortelius, M. (1996). The evolutionary history and biochronology of European and Southwest Asian Late Miocene and Pliocene hipparionine horses.

R.L. Bernor, V. Fahlbusch, H.W. Mittmann (Eds.), The Evolution of Western Eurasian Neogene Mammal Faunas, *Columbia Univ. Press*, 307-338.

Bernoulli, D., Graciansky, P.C. de, Monod, O. (1974). The extension of the Lycian nappes (SW Turkey) into the southwestern Aegean islands. *Eclogae Geologicae Helvetiae*, 67, 39-90.

Bonis, L. de., Bouvrain, G., Geraads, D., Koufos, G., Sen, S. and Tassy, P. (1994). Les gisements de mammiferes du Miocene superieur de Kemiklitepe, Turquie. *11. Biochronologie, paleoecologie et relations paleogeographiques. Bulletin du Museum national d'Histoire Naturelle*, Paris, 4e ser., 16, C (1), 225–40.

Bozkurt, E. (2003). Origin of NE-trending basins in western Turkey. *Geodinamica Acta*, 16, 61-81.

Büyükmeriç, Y. (2017). Molluscan biostratigraphy of early Miocene deposits of Kale-Tavas and Acıpayam basins (Denizli, SW Turkey). *Bulletin of Mineral Research & Exploration*, 155, 15-30.

Carroll, A.R., Bohacs, K.M. (1999). Stratigraphic classification of ancient lakes: balancing tectonic and climatic controls. *Geology*, 27, 99-102.

Cihan, M., Saraç, G., Gökçe, O. (2003). Insights into biaxial extensional tectonics: an example form the Sandıklı Graben, West Anatolia, Turkey. *Geological Journal* 38, 47-6.

Cipollari, P., Cosentino, D., Gliozzi, E. (1999). Extension- and compression-related basins in central Italy during the Messinian Lago-Mare event. *Tectonophysics*, 315, 163-185.

Colin, H. (1962). Fethiye-Antalya-Kaş-Finike (Güneybatı, Türkiye) bölgesinde yapılan jeolojik etüdler. *Bulletin of the Mineral Research and Exploration Institute of Turkey*, 59, 19-59.

Collins, A.S., Robertson, A.H.F. (1997). Lycian mélange, southwestern Turkey: an emplaced Late Cretaceous accretionary complex. *Geology*, 25, 255–258

Collins, A.S., Robertson, A.H.F. (1998). Processes of Late Cretaceous to Late Miocene episodic thrust-sheet translations in the Lycian Taurides, SW Turkey. *Journal of the Geological Society of London*, 155, 759-772.

Collins, A.S., Robertson, A.H.F. (1999). Evolution of the Lycian Allochthon, western Turkey, as a north-facing Late Palaeozoic to Mesozoic rift and passive continental margin. *Geological Journal*, 34, 107–138.

Collins, A.S., Robertson, A.H.F. (2003). Kinematic evidence for Late Mesozoic-Miocene emplacement of the Lycian Allochthon over the Western Anatolide Belt, SW Turkey. *Geological Journal*, 38, 295-310.

Darbaş, G. (2017). Stratigraphy and Ostracod assemblages of the Çameli Formation crop out Dalaman-Göcek (Muğla-SW Turkey), *17th Int. Multidisciplinary Scientific Geoconference*, 11, 531-539.

De Graciansky, P. C. (1972). Reserches géologiques dans le Taurus Lycien occidental. *Thèse Doctorat d'Etat, Université de Paris-Sud* Orsay no. 896, 762 pp.

Demirel, A., Mayda, S. (2014). A new Early Pleistocene mammalian fauna from Burdur Basin, SW Turkey. *Russian Journal of Theriology*, 13, 55-63.

Demirel, A., Mayda, S., Alçiçek, M.C., Kaya, T. Aytek, A.I. (2016). Kocakir-2: First Record of Early Pleistocene Canis and Hippopotamus from Burdur Basin (SW Turkey). *XIV EAVP Meeting*, 6-10 July, 2016, Haarlem, The Netherlands. p.39

Demirel, A., Mayda, S., Alçiçek, M.C., Kaya, T.T., Aytek, A.İ. (2017). Burdur ili ve ilçelerinde Neojen ve Pleistosen dönem fosil lokalitelerinin tespiti yüzey araştırması-2015. *TCKB 34. Araştırma Sonuçları Toplantısı*, 2, 245-255

Dumont, J. F., Uysal, Ş., Şjmşek, Ş., Karamanderesi, İ. H., Letouzey, J. (1979). Formation of the grabens in Southwestern Anatolia.*Bulletin of the Mineral Research and Exploration Institute of Turkey*, 92, 7–18.

Elitez, İ., Yaltırak, C., Sunal, G. (2017). A new chronostratigraphy (40Ar-39Ar and U-Pb dating) for the middle section of the Burdur-Fethiye shear zone, SW Turkey. *EGU General Assembly*, 19, EGU2017-5443, Austria.

Erakman, B., Meşhur, M., Gül, M.A., Alkan, H., Öztaş, Y., Akpınar, M. (1982a). Fethiye-Köyceğiz-Tefenni-Elmalı-Kalkan arasında kalan alanın jeolojisi. *Türkiye 6. Petrol Kongresi*, Ankara s. 23-31.

Erakman, B., Meşhur, M., Gül, M.A., Alkan, H., Öztaş, Y., Akpınar, M. (1982b). Toros projesine bağlı Kalkan-Köyceğiz-Çameli-Tefenni arasında kalan alanın jeolojisi ve hidrokarbon olanakları raporu (The geology and hydrocarbon potential of the Kalkan-Köyceğiz-Çameli-Tefenni region, as

a part of The Taurus Project). *The Turkish Petroleum Corporation (TPAO)*, Technical Report No: 1732, Ankara, Turkey.

Erakman, B., Alkan, H. (1986). Kalkan-Elmalı-Yeşilova-Acıpayam-Fethiye Arasının Jeoloji ve Petrol Olanakları (Geological and Oil Possibilities of the Area Between Kalkan-Elmalı-Yeşilova-Acıpayam-Fethiye). *TPAO Raporu* No: 2190 (unpublished).

Eronen, J.T., Ataabadi, M.M., Micheels, A., Karme, A., Bernor, R.L., Fortelius, M. (2009). Distribution history and climatic controls of the Late Miocene Pikermian chronofauna. *Proceedings National Academy of Science*, 106, 11867-11871

Geraads D. (2017). Late Miocene large mammals from Mahmutgazi, Denizli province, Western Turkey. *N. Jb. Geol. Palaont. Abh.*, 284 (3), 241-257.

Göktaş, F., Çakmakoğlu, A., Tarı, E., Sütçü, Y.F., Sarıkaya, H. (1989). Çivril-Çardak Arasının Jeolojisi [Geology of Çivril-Çardak area]. *Mineral Research & Exploration Institute of Turkey (MTA)*, Report No: 8701.

Görür, N. (ed.) (1998). Triassic to Miocene Palaeogeographic Atlas of Turkey. *Publication of İstanbul Technical University and Mineral Research and Explonation Directorate of Turkey*, 43 pp.

Görür, N., Sakınç, M., Barka, A., Akkök, R., Ersoy, Ş. (1995). Miocene to Pliocene paleogeographic evolution of Turkey and its surroundings. *Journal of Human Evolution*, 28, 309-324.

Guillou H. Vincent S. Nomade S. Platevoet B. Blamart D. (2017). Des la justesse des ages K-Ar: Exemple de la datation de deux domes trachytiques du Gölcük (Turquie). *Quaternaire*, 28, 141-148.

Hakyemez, H.Y. (1989). Geology and stratigraphy of the Cenozoic sedimentary rocks in the Kale-Kurbalık area, Denizli, southwestern Turkey. *Bulletin of Mineral Research & Exploration*, 109, 1-14.

Hakyemez, H.Y., Örçen, S. (1982). Muğla ve Denizli arasındaki (Güneybatı Anadolu) Senozoyik yaşlı çökel kayaların sedimantolojik ve biyostratigrafik incelemesi. *Mineral Research and Exploration Directorate of Turkey*, Scientific Report No: 7311, 237 pp.

Hayward, A.B. (1984). Sedimentation and basin formation related to ophiolite emplacement, Miocene, SW Turkey. *Sedimentary Geology*, 40, 105–129.

Hayward, A.B., Robertson, A.H.F. (1982). Direction of ophiolite emplacement inferred from Cretaceous and Tertiary sediments of an adjacent autochthon, the Bey Dağlari, SW Turkey, *Geol. Soc. Am. Bull.*, 93, 68-75.

Helvacı, C., Alçiçek, M.C., Gündoğan, İ., Gemici, Ü. (2013). Tectonosedimentary development and palaeoenvironmental changes in the Acıgöl shallow-perennial playa-lake basin, SW Anatolia, Turkey. *Turkish Journal of Earth Sciences* 22, 173-190.

Hilgen, F.J., Lourens, L.J., Van Dam J.A. (2012). The Neogene period. In: Gradstein, F.M., Ogg, J.G., Schmitz, M., Ogg, G. (Eds.), The Geologic Time Scale 2012. *Elsevier*, 923–978.

Howell, A., Jakckon, J., Copley, A., McKenzie, D., Nissen, E. (2017). Subduction and vertical coastal motions in the eastern Mediterranean. *Geophysical Journal International*, 211, 593-620.

İslamoğlu, Y., Atay, G., Gedik, F., Aydın, A., Hakyemez, A., Babayiğit, S., Sarıkaya, H. (2005). Batı Toroslar'daki Denizel Oligo-Miyosen Çökellerinin Biyostratigrafisi. *Mineral Research and Exploration Directorate of Turkey*, Report No: 10763, 155 pp.

Jiménez-Moreno, G., Popescu, S.-M., Ivanov, D., Suc, J.-P. (2007). Neogene flora, vegetation and climate dynamics in southeastern Europe and northeastern Mediterranean according to pollen records. In: Williams, M., Haywood, A. M., Gregory, F. J. & Schmidt, D. N. (eds) Deep-Time Perspectives on Climate Change: Marrying the Signal from Computer Models and Biological Proxies. *The Micropalaeontological Society, Special Publications. The Geological Society, London*, 503-516.

Bitelkin, D., Popescu, S.-M., Suc, J.-P., Quézel, P., Yavuz, N., Jiménez-Moreno, G., Safra, A., Namik Cagatay, M. (2015). Anatolia: a plant refuge area during the last 23 Million years according to pollen records from Turkey. *Review of Palaeobotany and Palynology*, 215, 1-22.

Jiménez-Moreno, G., Alçiçek, H., Alçiçek, M.C., Hoek Ostende, L.W. van den., Wesselingh, F.P. (2016). Letter to Editor "Vegetation and climatic cycles during the late Pliocene and early Pleistocene in SW Anatolia" Response to comments. *Quaternary Research*, 85, 476-477.

Jiménez-Moreno, G., Alçiçek, H., Alçiçek, M.C., Van den Hoek Ostende, L.W., Wesselingh, F.P. (2015). Vegetation and climatic cycles during the late Pliocene and early Pleistocene in SW Anatolia. Turkey. *Quaternary Research*, 84, 448–456.

Jolivet, L., Menant, A., Sternai, P., Rabillard, A., Arbaret, L., Augier, R., Laurent, V., Beaudoin, A., Grasemann, B., Huet, B., Labrousse, L., Le Pourhiet, L. (2015). The geological signature of a slab tear below the Aegean. *Tectonophysics*, 659, 166-182.

Kahlke, R.-D., García, N., Kostopoulos, D.S., Lacombat, F., Lister, A.L., Mazza, P., Spassov, N., Titov, V.V. (2011). Western Palaearctic palaeoenvironmental conditions during the Early and early Middle Pleistocene inferred from large mammal communities, and implications for hominin dispersal in Europe. *Quaternary Science Reviews*, 30, 1368-1395.

Karabacak, V. (2011). Geological, geomorphological and archeoseismological observations along the Cibyra fault and their implications on the regional tectonic of SW Turkey, *Turkish Journal of Earth Sciences*, 20, 429-447.

Karaman, E. (1986). Burdur dolayının genel stratigrafisi. *Akdeniz Üniversitesi Isparta Mühendislik Fakültesi Dergisi* 2, 23-36.

Kaya, T. (1993). Late Miocene Perissodactyla from Sazak (Kale-Denizli). *Bulletin of the Mineral Research and Exploration*, 115, 23-31.

Kaya, T. (1993). Sazak (Kale-Denizli) Geç Miyosen Perissodactyla'sı. *MTA Dergisi*, 115, 35-42.

Kaya, T., Forstén, A. (1999). Late Miocene Ceratotherium and Hipparion (Mammalia, Perissodactyla) from Düzyayla (Hafik, Sivas), Turkey. *Géobios*, 32, 743–748.

Kaya, T., Mayda, S., Alçiçek, M.C. (2008). Denizli – Çal Yöresinde Yeni bir Geç Miyosen Memeli faunası. Proc. IX Palaentol.-Stratigraphy Confer. Denizli, Turkey.

Kaya, T., Mayda, S., Kostopoulos, D., Alçiçek, M.C., Merceron, G., Tan, A., Karakütük, S., Giesler, A.K., Scott, S.S. (2012). Şerefköy-2, a new late Miocene mammalian locality from the Yatağan Formation, Muğla, SW Turkey. *Comptes Rendus Palevol*, 11, 5-12.

Kaymakçı, N., Langereis, C., Özkaptan, M., Özacar, A.A., Gülyüz, E., Uzel, B., Sözbilir, H., Koç. A. (2018). Paleomagnetic evidences for upper plate response to a STEP fault, SW Anatolia. *Earth and Planetary Science Letters*, 498, 101-115.

Kaymakçı, N., (2006). Kinematic development and paleostress analysis of the Denizli Basin (Western Turkish): implications of spatial variation of relative paleostress magnitudes and orientations. *Journal of Asian Earth Sciences*, 27, 207–222.

Koç, A., Van Hinsbergen, D.J.J., Kaymakçı, N., Langereis, C.G. (2016). Late Neogene oroclinal bending in the central Taurides: A record of terminal eastward subduction in southern Turkey? *Earth and Planetary Science Letters*, 434, 75-90.

Koçyiğit, A., Deveci, Ş. (2007). A N-S-trending active extensional structure, the Şuhut (Afyon) graben: commencement age of the extensional neotectonic period in the Isparta Angle, SW Turkey. *Turkish Journal of Earth Sciences*, 16, 391-416.

Konak, N. (2002). Geological map of Turkey in 1/500.000 scale: İzmir sheet. *Mineral Research and Explaniton Directorate of Turkey (MTA)*, Ankara.

Konak, N., Akdeniz, N., Çakir, M.H. (1986). Çal-Çivril-Karahallı dolayının jeolojisi (The geology of the Çal-Çivril-Karahallı area); *Mineral Res. Expl. Inst. Turkey (MTA)*, Scientific Report No: 8945, (in Turkish, unpublished).

Konak, N., Şenel, M. (2002). Geological map of Turkey in 1/500.000 scale: Denizli sheet. *Publication of Mineral Research and Exploration Directorate of Turkey (MTA)*.

Kostopoulos, D.S. and Karakütük, S. (2015). Late Miocene bovids from Şerefköy-2, SW Turkey, and their position within the sub- Paratethyan biogeographic province. *Acta Palaeontologica Polonica* 60 (1), 49–66.

Koufos, G. D., Kostopoulos, D. S. (1994). The late Miocene mammal localities of Kemiklitepe (Turkey). 3. Equidae. *Bulletin du Muséum national d'Histoire naturelle Paris* 4 e sér., 16, 41-80.

Koufos, G.D., Mayda, S. Kaya, T. (2018). New carnivoran remains from the late Miocene of Turkey. *PalZ*, 92(1), 131-162.

Krijgsman W. Tesakov A. Yanina T. Lazarev S. Danukalova G. Van Baak G.C.G. Agustí J. Alçiçek M.C. Aliyeva E. Bista D. Bruch A. Büyükmeriç Y. Bukhsianidze M. Flecker R. Frolov P. Hoyle T.M. Jorissen E.L. Kirscher U. Koriche S.A. Oms O. Rausch L. Singarayer J. Stoica M. Van de

Velde S.V. Titov V.V. Wesselingh F.P. 2018. Quaternary time scales for the Pontocaspian domain: interbasinal connectivity and faunal evolution. *Earth Science Reviews (in press)*

Lefevre, C., Bellon, H., Poisson, A. (1983). Presence de leucitites dans le volcanisme Pliocene de la region d'Isparta (Taurus occidentales, Turkquie). *Comptes Rendus de l'Académie des Sciences de Paris*. 297, 369-372.

Luttig, G., Steffens, D. (1976). Explanatory Notes for the Paleogeographic Atlas of Turkey from Oligocene to Pleistocene. *Bundesanstalt für Geowissenchaften und Rahstoffe*, Hannover, 64 pp.

Mayda, S. and Alçiçek, M.C. (2008). A new Late Miocene paleomammalian fauna from Uşak region (Uşak-Karabeyli). *9th. Palaeontology-Stratigraphy Workshop. Denizli.* Abstract book, 24-25 p.

Mayda, S. (2014). The Updated Late Miocene Mammalian Faunas of Özlüce, Şerefköy and Salihpaşalar from Yatağan Basin, Muğla, SW Turkey. *8th International Symposium on Eastern Mediterranean Geology, Muğla*. 13-17 November, 176 p.

Mayda, S., Alçiçek, M.C., Demirel, F.A., Alçiçek, H. (2017). The first record of a Villafranchian small cervid "Croizetoceros" from Turkey. *15th RCMNS Congress (Regional Committee on Mediterranean Neogene Stratigraphy),* 3-6 September, Athens, Greece.

Mayda, S., Alçiçek,M.C., Kaya, T., Demirel, A., Halaçlar,K. and Kanık,D. (2016). Systematic, Biostratigraphic And Paleobiogeographic Reevaluation of The Mammalian Faunas From The Turkish Villafranchian Localities of Kamisli, Gulyazi and Y.Sogutonu. *XIV EAVP Meeting*, 6-10 July, 2016, Haarlem, The Netherlands 40 p.

Meşhur, M., Akpınar, M. (1984). Yatağan-Milas-Bodrum-Karacasu-Kale-Acıpayam-Tavas civarlarının jeolojisi ve petrol olanakları (The geology and petroleum potential of Yatağan-Milas-Bodrum-Karacasu-Kale-Acıpayam-Tavas region). *The Turkish Petroleum Corporation (TPAO),* Technical Report No: 1963, Ankara, Turkey.

Nemec, W., Kazancı, N., Mitchell, J.G. (1998). Pleistocene explosions and pyroclastic currents in west-central Anatolia. *Boreas*, 27, 311-332

Nemec. W., Alçiçek, M.C., Özaksoy, V. (2018). Sedimentation in a foreland basin within synorogenic orocline: Palaeogene of the Isparta Bend, Taurides, SW Turkey. *Basin Research*, 30, 650-670

Oppenheim, P. (1919). Das Neogen in Kleinasien. *Zeitschrift Deutsche Geologische Gesellschaft*, 70, 1–210.

Oruç, S. (2009). The Fossils of Bovidae (Artiodactyla) From Denizli (Sazak) Neogene Mammalian Fauna and Their Biochronological, Paleobiogeographic and Paleoclimatologic Meanings. *Ms Thesis. Ege University (Unpublished).* İzmir. 154 p.

Över, S., Özden, S., Kamacı, Z., Yılmaz, H., Ünlügenç, U.C., Pınar, A. (2016a). Upper crust response to geodynamic processes beneath Isparta Angle, SW Turkey: Revealed by CMT solution of earthquakes. *Tectonophysics*, 687, 94-104.

Över, S., Özden, S., Pınar, A., Yılmaz, H., Kamacı, Z., Ünlügenç, U.C. (2016b). Late Cenozoic stres state distributions at the intersection of the Hellenic and Cyprus arcs, SW Turkey. *Journal of Asian Earth Sciences*, 132, 94-102

Över, S., Özden, S., Yılmaz, H., Pınar, A., Ünlügenç, U.C., Kamacı, Z. (2013a). Plio-Quaternary stres regime in the Eşen Çay Basin, SW Turkey. In: Robertson, A.H.F., Parlak, O. & Unlugenc, U.C. (eds) Geological Development of Anatolia and the Easternmost Mediterranean Region. *Geological Society, London,* Special Publications, 372, 547-560.

Över, S., Pınar, A., Özden, S., Yılmaz, H., Ünlügenç, U.C., Kamacı, Z. (2010). Late Cenozoic stress field in the Çameli Basin, SW Turkey. *Tectonophysics*, 492, 60-72.

Över, S., Yılmaz, H., Pınar, A., Özden, S., Ünlügenç, U.C., Kamacı, Z. (2013b). Plio-Quaternary stres state in the Burdur Basin, SW Turkey. *Tectonophysics*, 588, 56-68.

Özcan, E., Less, G., Báldi-Beke, M., Kollányi, K., Acar, F., (2009). Oligo-Miocene foraminiferal record (Miogypsinidae, Lepidocyclinidae and Nummulitidae) from the Western Taurides (SW Turkey): Biometry and implications for the regional geology. *Journal of Asian Earth Sciences*, 34, 740-760.

Özgül, N. (1976). Toroslar'ın bazı temel jeoloji özellikleri. *Bulletin of the Geological Society of Turkey, 19*, 65-78.

Özgül, N. (1984). Stratigraphy and tectonic evolution of the Central Taurides. *Geology of the Taurus belt*, 77-90.

Özkaptan, M., Kaymakçı, N., Langereis, C.G., Gülyüz, E., Özacar, A., Uzel, B., Sözbilir, H. (2018). Age and kinematics of the Burdur Basin: Inferences for the existence of the Fethiye Burdur Fault Zone in SW Anatolia (Turkey). *Tectonophysics*, 744, 256-274

Özsayın, E. (2016). Relative tectonic activity assesment of the Çameli Basin, Western Anatolia, using geomorphic indices. *Geodinamica Acta*, 28, 241-253.

Pamir H.N. (1974). 1/500 000 ölçekli Türkiye jeoloji haritası (Denizli). *MTA Ens. yayını*, 83 pp.

Paton, S.M. (1992). The relationship between extension and volcanism in western Turkey, the Aegean Sea, and central Greece. *Unpubl. PhD Thesis, Cambridge University*, 300 pp.

Pickford, M. (2016). Hippopotamodon Erymanthius (Suidae, Mammalia), from Mahmutgazi, Denizli-Çal Basin, Turkey. *Fossil Imprint*, 72, 183-201.

Platevoet, B., Scaillet, S., Guillou, H., Blamart, D., Nomade, S., Massault, M., Poisson, A., Elitok, Ö., Özgür, N., Yağmurlu, F., Yılmaz, K. (2008). Pleistocene eruptive chronology of the Gölcük volcano, Isparta Angle, Turkey. *Quaternaire*, 19, 147–156.

Poisson, A., Yağmurlu, F., Bozcu, M., Şentürk, M. (2003). New insights on the tectonic setting and evolution around the apex of the Isparta Angle (SW Turkey). *Geological Journal*, 38, 257–282.

Poisson, A. (1984). The extension of the Ionian trough into southwestern Turkey. In Dixon, J.E. & Robertson, A.H.F. (eds.): *The Geological Evolution of the Eastern Mediterranean*, 17, 241–249.

Price, S.P. (1989). Sedimentation and neotectonics of the Burdur region, SW Turkey. *Unpubl. PhD Thesis*, University of Leicester.

Price, S.P., Scott, B. (1991). Pliocene Burdur basin, SW Turkey: tectonics, seismicity and sedimentation. *Journal of the Geological Society of London*, 148, 345–354.

Price, S.P., Scott, B. (1994). Fault–block rotations at the edge of a zone of continental extension: southwest Turkey. *Journal of Structural Geology*, 16 (3), 381–392.

Price, S.P., Scott, B.C. (1989). A revised lithostratigraphy of the Burdur Formation, SW Turkey. *Bulletin of the Technical University İstanbul*, 42, 1–27.

Purvis, M., Robertson, A. (2004). A pulsed extension model for the Neogene-Recent E-W trending Alaşehir (Gediz) Graben and the NW-SE trending Selendi and Gördes Basins, E. Turkey. *Tectonophysics*, 391, 171-201.

Robertson, A.H.F., Dixon, J.E. (1984). Introduction: aspects of the geological evolution of the eastern Mediterranean; In: Dixon, J.E., Robertson, A.H.F. (Eds.), The Geological Evolution of the Eastern Mediterranean. *Geological Society of London*, Special Publication, 17, 1-74.

Robertson, A.H.F., Poisson, A., Akıncı, Ö. (2003). Developments in research concerning Mesozoic-Tertiary Tethys and neotectonics in the Isparta Angle, SW Turkey. *Geological Journal*, 38, 195-234.

Rutte, E., Becker–Platen, J.D. (1980). Cypriniden–Schlundzähne (Pisces) aus dem Känozoikum der Turkei. *Newsletters on Stratigraphy*, 8, 191-222.

Saraç, G. (2003). The vertebrate fossil localities of Turkey. Scientific Report No. 10609, *General Directorate of the Mineral Research and Exploration of Turkey (MTA)*, Ankara, 208 pp.

Schmidt-Kittler, N. (1976). Carnivores from the Neogene of Asia Minor. *Palaeontographica, Abt. A*, 155, 1–131.

Şen, Ş. (1977). La faune de Rongeurs pliocène de Çalta (Ankara, Turquie). *Bull. Mus. nat. Hist. natur*., 3 (61), 89-171.

Şen, Ş. (1998). Rodentia and Lagomorpha. In. Şen, Ş. (ed) Pliocene Vertebrate Locality of Çalta, Ankara, Turkey. *Geodiversitas*, 20 (3), 359-378.

Şen, Ş., Seyitoğlu, G., Karadenizli, L., Kazanci, N., Varol, B., Araz, H. (1998). Mammalian Biochronology of Neogene Deposits and its Correlation with the Lithostratigraphy in the Çankırı–Çorum Basin, Central Anatolia, Turkey. *Eclogae Geologica Helvetiae*, 91, 307–320.

Şenel, M. (1997a). Geological maps of Turkey in 1:100 000 scale: Isparta K10 sheet, *Mineral Research and Exploration Directorate of Turkey (MTA)*, Ankara, 20 pp.

Şenel, M. (1997b). Geological maps of Turkey in 1:100.000 scale: Isparta J10 sheet. *Mineral Research and Exploration Directorate of Turkey (MTA)*, Ankara, 18 pp.

Şenel, M. (1997c). Geological maps of Turkey in 1:100.000 scale: Denizli J9 sheet. *Mineral Research and Exploration Directorate of Turkey*, Ankara, 18 pp.

Şenel, M. (2002). Geological map of Turkey in 1/500.000 scale: Konya sheet. *Mineral Res. Expl. Direct. Turkey (MTA)*, Ankara, Turkey.

Şenel, M. (2010). Geological maps of Turkey in 1:100.000 scale: Denizli N23 sheet. *Mineral Research and Exploration Directorate of Turkey (MTA)*, Ankara, 20 pp.

Şenel, M., Selçuk, H., Bilgin, Z.R., Şen, A.M., Karaman, T., Dinçer, M.A., Durukan, E., Arbas, A., Örçen, S., Bilgi, C., (1989). Çameli (Denizli)-Yeşilova (Burdur)-Elmalı (Antalya) ve dolayının jeolojisi. *Mineral Research and Exploration Directorate of Turkey,* Scientific Report No: 9429, 344 pp.

Şengör, A. M. C., Yılmaz, Y. (1981). Tethyan evolution of Turkey: A plate tectonic approach. *Tectonophysics,* 75, 181-241.

Şengör, A.M.C., Görür, N., Şaroğlu, F. (1985). Strike-slip deformation, basin formation and sedimentation: strike-slip faulting and related basin formation in zones of tectonic escape: Turkey as a case study. In: Biddle, K.B., Blick, N.C. (eds) Strike-Slip Deformation, Basin Formation and Sedimentation. *SEPM Spec Publ.,* 37, 227–264.

Seyitoglu, G., Alcicek, C., Isik, V., Alcicek, H., Mayda, S., Varol, B., Yılmaz, I., Esat, K. (2009). The stratigraphical position of Kemiklitepe fossil locality (Uşak-Eşme) revisited: Implications for the Late Cenozoic sedimentary basin development and extensional tectonics in western Turkey. *Neues Jahrbuch für Geologie und Palaontologie.* 251(1), 1-15.

Sickenberg, O., Becker-Platen, J.D., Benda, L., Berg, D., Engesser, B., Gazlry, W., Heissig, K., Hünermann, K.A., Sondaar, P.Y., Schmidt-Kittler, N., Staesche, K., Staesche, U., Steffens, P., Tobien, H. (1975). Die Gliederung des höheren Jungtertiärs und Altquartärs in der Turkei nach Vertebraten und ihre Bedeutung für die internationale Neogen-Stratigraphie. *Geol. Jahrb.*, 1–167.

Sickenberg, O., Tobien, H. (1971). New Neogene and Lower Quaternary vertebrate faunas in Turkey. *Newsletters on Stratigraphy,* 1, 51-61.

Sözbilir, H. (2005). Oligo-Miocene extension in the Lycian orogen: evidence from the Lycian mollase basin, SW Turkey. *Geodinamica Acta,* 18, 255-282.

Spratt, T.A.B., Forbes, E. (1847). Travels in Lycia, Milyas and the Cibyrates. *Van Voorst*, London, 244 pp.

Sulpizio, R., Alçiçek, M.C., Zanchetta, G., Solari, L. (2013). Recognition of the Minoan tephra in the Acigol Basin, western Turkey: implications for inter archive correlations and fine ash dispersal. *Journal of Quaternary Science,* 28, 329-335.

Sun, S. (1990). Denizli-Uşak Arasının Jeolojisi ve Linyit Olanakları (Geology and Lignite Potential of Denizli-Uşak Region). *Mineral Research and Exploration Directorate of Turkey (MTA)*, Scientific Report No: 9985, Ankara (in Turkish), 92 pp.

Sylvestrou, I.A., Kostopoulos, D.S. (2007). Pseudomeriones megistos nov. sp. (Gerbillinae, Mammalia) from the latest Miocene of Northern Greece and its phylogenetic relationships. *Geobios,* 40, 833-848.

Ten Veen, J.H. (2004). Extension of Hellenic forearc shear zones in SW Turkey: the Pliocene-Quaternary deformation of the Eşen Çay Basin. *Journal of Geodynamics,* 37, 181-204.

Ten Veen, J.H., Boulton, S.J., Alçiçek, M.C. (2009). From palaeotectonics to neotectonics in the Neotethys realm: the importance of kinematic decoupling and inherited structural grain in SW Anatolia (Turkey). *Tectonophysics,* 473, 261-281.

Tuna, V. (1999). Yukarısazak (Kale-Denizli) Geç Miyosen Artiodactyl'leri (Mammalia). *MTA Dergisi,* 121, 73-82.

Tunoğlu, C., Bayhan, E. (1996). Burdur Havzası Pliyosen istifinin mikropaleontolojik (ostracod) incelemesi ve ortamsal yorum. *MTA Dergisi*. 118, 9–16.

Turan, N. (2002). Geological map of Turkey in 1/500.000 scale: Ankara sheet. *Publication of Mineral Research and Explaniton Directorate of Turkey (MTA)*, Ankara.

Van den Hoek Ostende, L.W. van den., Diepeveen, F., Tesakov., A., Saraç, G., Mayhew, D., Alçiçek, M.C. (2015a). On the brink: micromammals from the latest Villanyian from Bıçakçı (Anatolia). *Geological Journal,* 50, 230-245.

Van den Hoek Ostende, L.W. van den., Gardner, J.D., Van Bennekom, L., Alçiçek, M.C., Murray, A.M., Wesselingh, F.P., Alçiçek, H., Tesakov, A.S. (2015b). Ericek, a new Pliocene vertebrate locality from the Çameli Basin (SW Anatolia, Turkey). *Palaeobiodiversity and Palaeoenvironments,* 95, 305-320.

Vialet, A., Guipert, G., Alçiçek, M.C. (2012). Homo erectus found still further west: Reconstruction of the Kocabaş cranium (Denizli, Turkey). *Comptes Rendus Palevol,* 11, 89-95

Waldron, J.W.F. (1981). Mesozoic sedimentary and tectonic evolution of the northeast Antalya Complex. Eğridir, SW. Turkey. *Ph.D. Thesis, Edinburg University*, U.K., 312 pp.

Weerd, A. van de., Reumer, J. W. F., Vos, J. de. (1982). Pliocene mammals from the Apolakkia Formation (Rhodes, Greece). *Proceedings of the Koninklijke Nederlandse Academie van Wetenschappen,* Section B, 85 (1), 89-112.

Wesselingh, F.P., Alçiçek, H. (2010). A new cardiid bivalve from the Pliocene Baklan Basin (Turkey) and the origin of modern ponto-caspian taxa. *Palaeontology*, 53, 711-719.

Westaway, R., Guillou, H., Yurtmen, S., Demir, T., Scaillet, S., Rowbotham, G. (2005). Constraints on the timing and regional conditions at the start of the present phase of crustal extension in western Turkey, from observations in and around the Denizli region. *Geodinamica Acta*, 18, 209-238.

Woodcock, N.H., Robertson, A.H.F. (1982). Wrench and thrust tectonics along a Mesozoic-Cenozoic continental margin: Antalya Complex, SW Turkey. *Journal of the Geological Society London*, 139, 147-163.

Zanchi, A., Kissel, C., Tapırdamaz, C. (1993). Late Cenozoic and Quaternary brittle continental deformation in western Turkey. *Bulletin de la Societe Geologique de France*, 164, 507-517.

Captions

Table 1. Biostratigraphic data from the Neogene marine and terrestrial sedimentary units exposed in Çameli Basin area of SW Anatolia (marine biota: Becker-Platen 1970, Hakyemez & Örçen 1982, Meşhur & Akpınar 1984, Konak et al. 1986, Şenel et al. 1989, Şenel 1997a,b, İslamoğlu et al. 2005, Şenel 2010, Akdeniz 2011a, b, Büyükmeriç 2017; terrestrial biota Atalay 1980, Karaman 1986, Göktaş et al. 1989, Price & Scott 1989, Price & Scott 1991, Sun 1990; Kaya 1993, Tuna 1999, Alçiçek 2001, Saraç 2003, Alçiçek 2007, Şenel 2010, Akdeniz 2011a, b, Kaya et al. 2012, Van den Hoek Ostende et al. 2015a,b, Jimenez-Moreno et al. 2015, Alçiçek et al. 2017a,b, Sickenberg & Tobien 1971, Sickenberg et al. 1975, Alçiçek et al. 2005, Wesselingh & Alçiçek 2010, Alçiçek et al. 2012, Alçiçek et al. 2013a,b, Alçiçek & Alçiçek 2014, Demirel & Mayda 2014, Pickford 2016, Geraads 2017, Demirel et al. 2016, 2017, Darbaş 2017). Note that the terrestrial biota is well accordance with the geochronological constraints provided by Paton 1992, Westaway et al. 2005, Sulpizio et al. 2013, Lefevre et al. 1983, Platevoet et al. 2008, Elitez et al. 2017, Athanassas et al. 2018, see text for explanation.

Fig.1. (A) Tectonic map of the Aegean and western Turkey showing the major tectonic structures (Bozkurt 2003); (B) Overview of the prominent extensional basins of western Anatolia surrounding the Çameli Basin (based on Konak 2002, Konak & Şenel 2002, Şenel 2002, Turan 2002). The fossil localities subjected in this study are indicated. See Fig. 2 and 3 for the stratigraphic position of the fossil sites and Table 1 for their contents.

Fig.2. Biostratigraphic range and the biochronologic interpretation of Turolian and Plio-Pleistocene taxa from the SW Anatolian terrestrial basins. (1) Alçiçek et al. 2017, (2) Hoek Ostende et al. 2015a, (3) Hoek Ostende et al. 2015b, (4) Demirel & Mayda 2014, (5) Alçiçek et al. 2013, (6) Demirel et al. 2016, 2017, (7) Mayda et al. 2016, (8) Alpagut et al. 2015, (9) Mayda et al. 2017, (10) Wesseling & Alçiçek 2010, (11) Alçiçek et al. 2013a, b, (12) Alçiçek et al. 2012, (13) Geraads 2017, (14) Pickford 2016, (15) Mayda 2014, (16) Oruç 2009, (17) Tuna 1999, (18) Kaya 1993, (19) Alçiçek 2007, (20) Alçiçek et al. 2017, (21) This study. The chronostratigraphic stages stand on Hilgen et al. (2012). The colour codes correspond to the facies associations (Af: Alluvial-fan, F: Fluvial, L: Lacustrine). See Fig. 1 and 3 and Table 1 for the locations and stratigraphic positions of the fossil sites.

Fig.3. Comparative stratigraphy for the synchronous extensional orogen-top basins in SW Anatolia depicted by the biostratigraphic evidence: Çal (Alçiçek et al. 2012, Alçiçek & Alçiçek 2014, Pickford 2016), Baklan (Sickenberg & Tobien 1971, Sickenberg et al. 1975, Konak et al. 1986, Sun 1990; Saraç 2003, Westaway et al. 2005, Wesselingh & Alçiçek 2010, Alçiçek et al. 2013a, Pickford 2016, Geraads 2017), Acıgöl (Göktaş et al. 1989, Sulpizio et al. 2013, Alçiçek et al. 2013a,b), Burdur (Sickenberg & Tobien 1971, Lefevre et al. 1983, Karaman 1986, Price 1989, Price & Scott 1989, Price & Scott 1991, Saraç 2003, Platevoet et al. 2008, Alçiçek et al. 2013a,b, Demirel & Mayda 2014, Alçiçek et al. 2017b, Demirel et al. 2016, 2017, Özkaptan et al. 2018), Çameli (Becker-Platen 1970, Erakman et al. 1982a,b, Meşhur & Akpınar 1984, Erakman & Alkan 1986, Saraç 2003, Alçiçek et al. 2005, Akdeniz 2011a, Van den Hoek Ostende et al. 2015a,b, Jimenez-Moreno et al. 2015, 2016, Elitez et al. 2017, Alçiçek et al. 2017a), Eşen (Becker-Platen 1970, Alçiçek 2007) and Beyağaç (Atalay 1980, Kaya 1993, Tuna 1999, Akdeniz 2011b). The chronostratigraphic stages stand on Hilgen et al. (2012). The oldest age of these orogen-top basins in SW Anatolia is early Turolian. The marine transgression was extant in the region during the Burdigalian which was followed by the final advance of Lycian nappes and caused a regional uplift during the Langhian-Tortonian elsewhere in SW Anatolia (Becker-Platen 1970, Hakyemez & Örçen 1982, Meşhur & Akpınar 1984, Şenel et al. 1989, Hakyemez 1989, Sözbilir 2005, Alçiçek 2001, Konak & Şenel 2002, İslamoğlu et al. 2005, Alçiçek & Ten Veen 2008, Şenel 2010, Akdeniz 2011a, b, Büyükmeriç 2017, Alçiçek et al. 2018). The readers are referred to Alçiçek (2010), Alçiçek et al. (2013a), Alçiçek (2015), Alçiçek et al. (2017b) and Alçiçek et al. (2018) for further correlative stratigraphy of the SW Anatolian Neogene basins. For the geographic locations of these basins, see the geological maps by the MTA (The Geological Survey of Turkey, Konak & Şenel 2002, Konak 2002, Şenel 2002, Turan 2002) and the compilation by Ten Veen et al. (2009). The tectonic information is compiled from Ten Veen et al. (2009), Jolivet et al.

(2015), Över et al. (2010, 2016), Howell et al. (2017) and Kaymakçı et al (2018). Note that the SW Anatolian terrestrial basins are strongly synchronic and compatible to the lithostratigraphic *Standard Profile* (SP) which was initially proposed for the lithostratigraphical subdivision of entire SW Anatolian Neogene formations by Becker-Platen (1970). See Fig. 1 for the location of the basins, and Fig. 2 for the stratigraphic position of the fossil sites.

Figure

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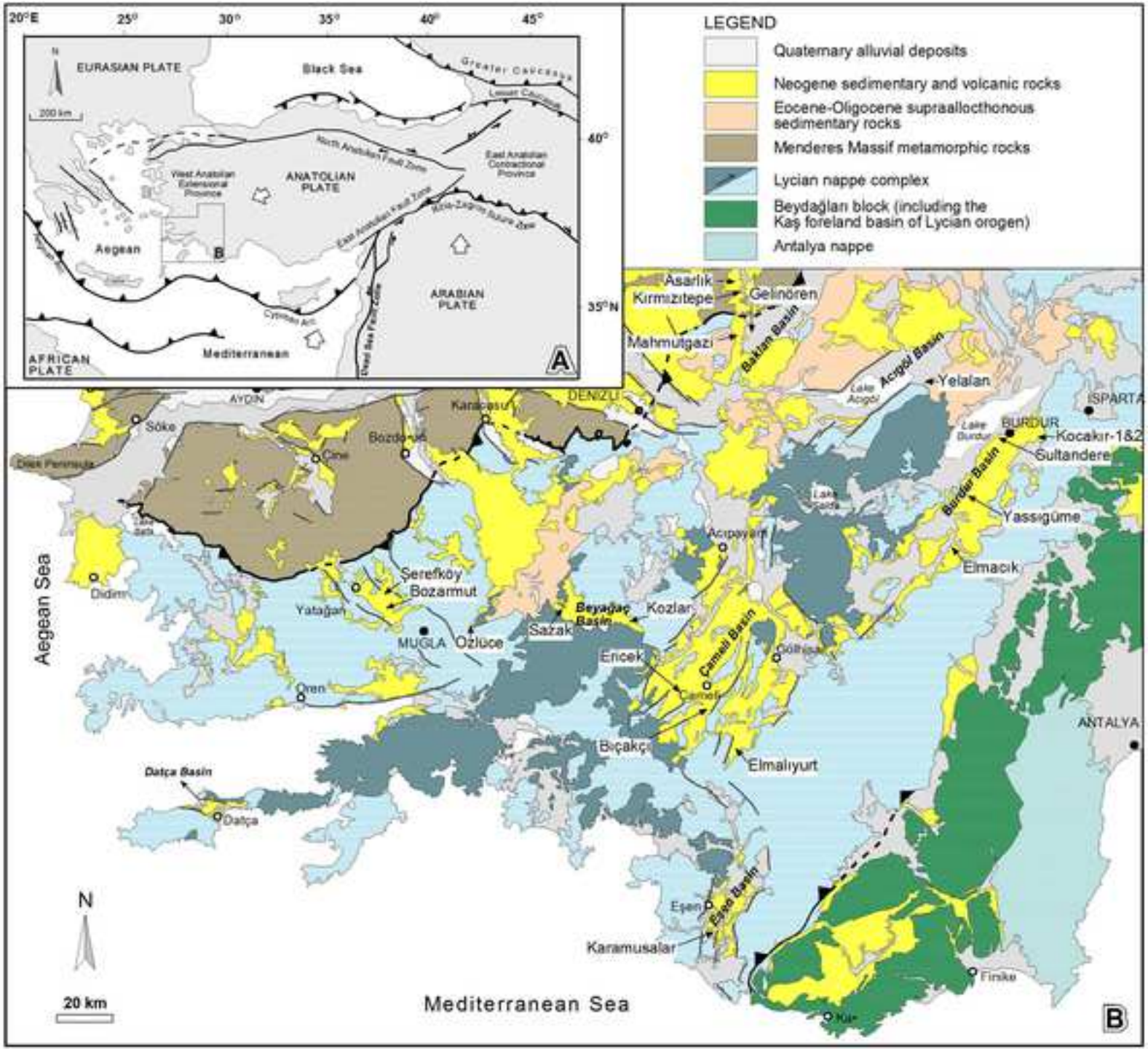

Figure

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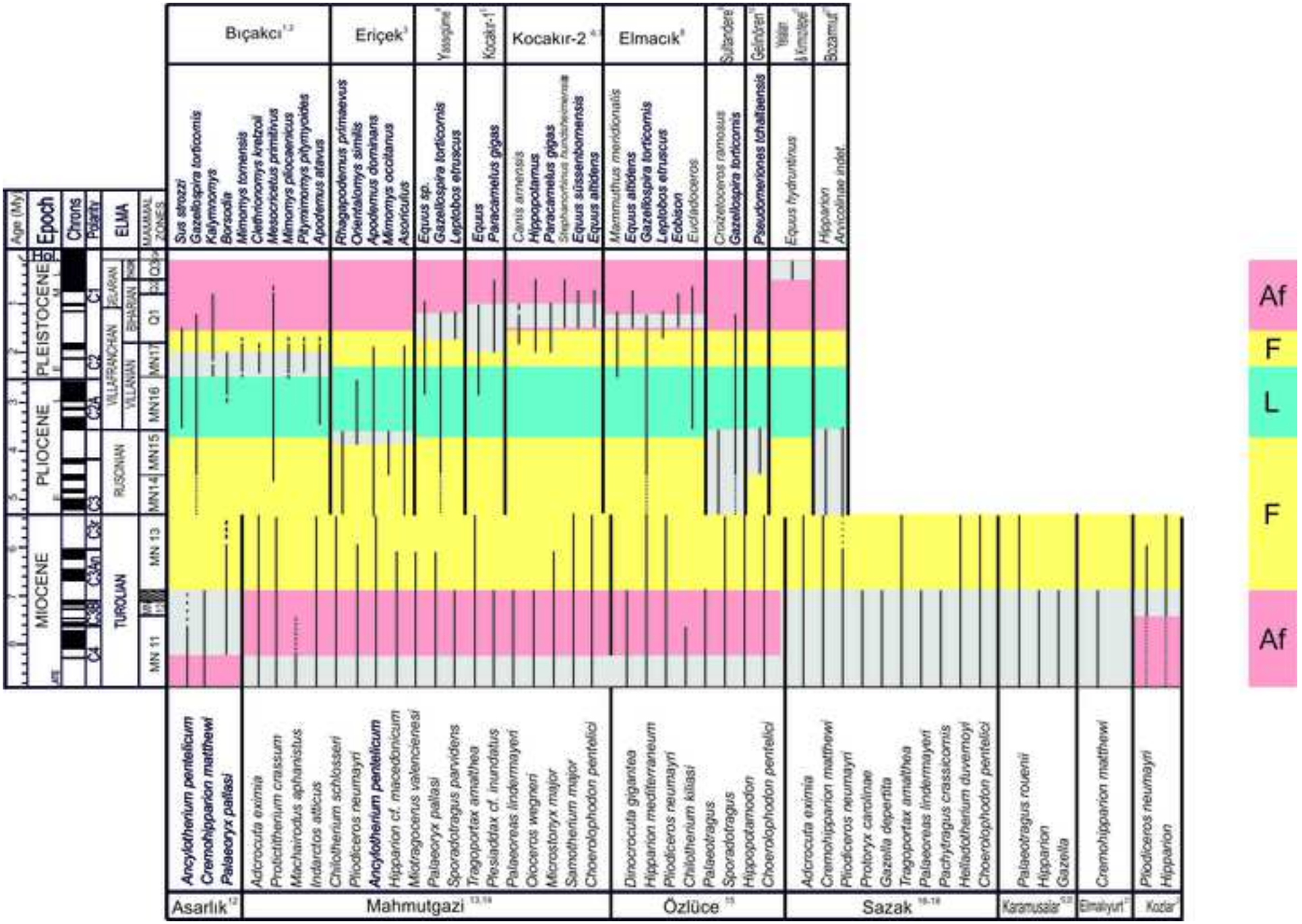

Figure

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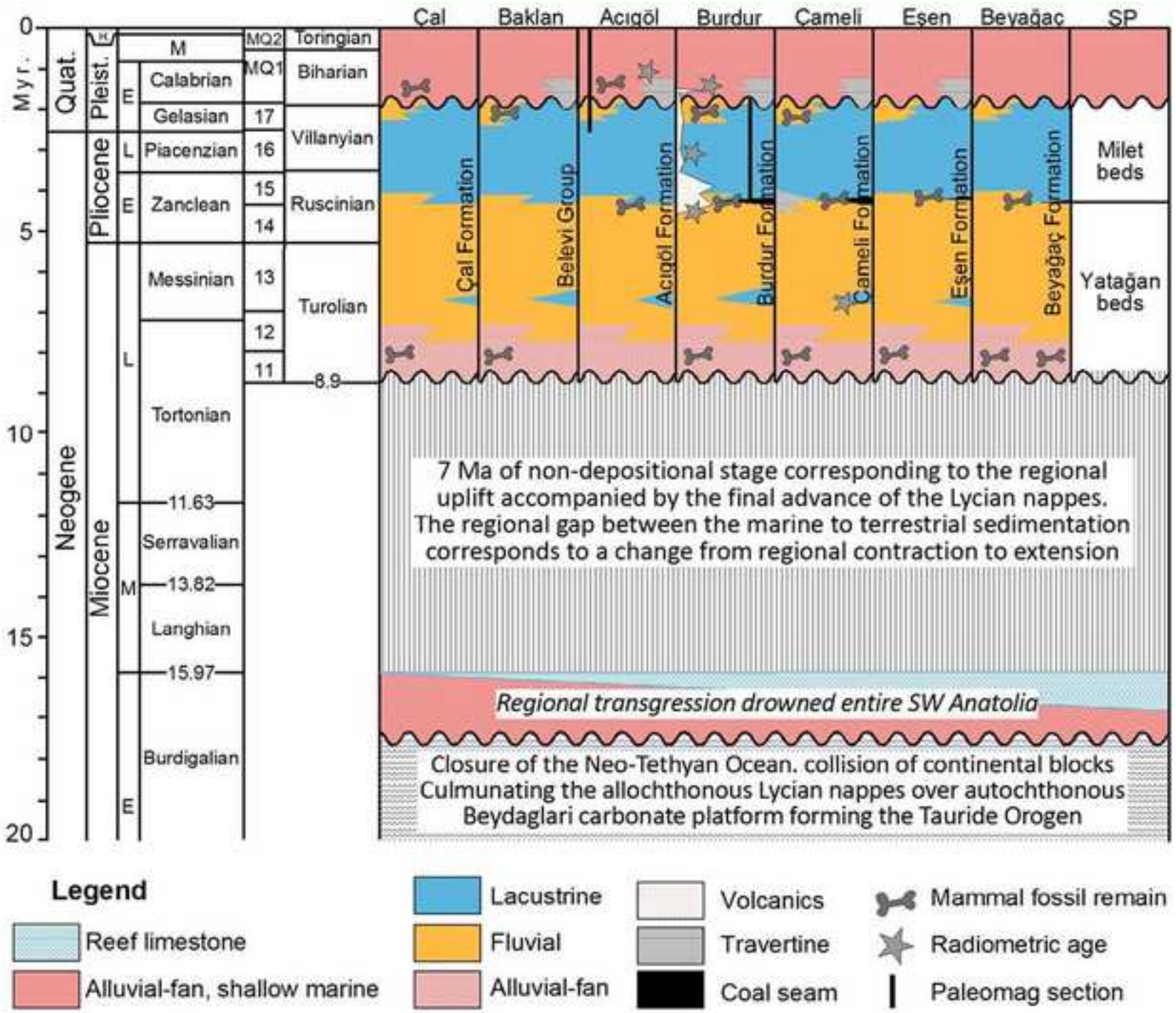

Table

Table 1. Biostratigraphic data from the Neogene marine and terrestrial sedimentary units exposed in Çameli Basin area of SW Anatolia (marine biota: Becker-Platen 1970, Hakyemez & Örçen 1982, Meşhur & Akpınar 1984, Konak et al. 1986, Şenel et al. 1989, Şenel 1997a,b, İslamoğlu et al. 2005, Şenel 2010, Akdeniz 2011a, b, Büyükmeriç 2017; terrestrial biota Atalay 1980, Karaman 1986, Göktaş et al. 1989, Price & Scott 1989, Price & Scott 1991, Sun 1990; Kaya 1993, Tuna 1999, Alçiçek 2001, Saraç 2003, Alçiçek 2007, Şenel 2010, Akdeniz 2011a, b, Kaya et al. 2012, Van den Hoek Ostende et al. 2015a,b, Jimenez-Moreno et al. 2015, Alçiçek et al. 2017a,b, Sickenberg & Tobien 1971, Sickenberg et al. 1975, Alçiçek et al. 2005, Wesselingh & Alçiçek 2010, Alçiçek et al. 2012, Alçiçek et al. 2013a,b, Alçiçek & Alçiçek 2014, Demirel & Mayda 2014, Pickford 2016, Geraads 2017, Demirel et al. 2016, 2017, Darbaş 2017). Note that the terrestrial biota is well accordance with the geochronological constraints provided by Paton 1992, Westaway et al. 2005, Sulpizio et al. 2013, Lefevre et al. 1983, Platevoet et al. 2008, Elitez et al. 2017, Athanassas et al. 2018, see text for explanation.

Unit	**Fossil assemblages**	**Age**
Alluvial-fan	**Çal-Kırmızıtepe locality:** *Equus hydruntinus* (late Pleistocene, Alçiçek et al. 2012) **Acıgöl:** *Equus hydruntinus* (late Pleistocene, Alçiçek et al. 2013) **Burdur Basin:** 1.50±0.18; 1.38±0.13 Ka (Nemec et al. 1998), 115±3 to 24±2 Ka (Platevoet et al. 2008) **Baklan:** *Pseudomeriones tchaltaensis (*Wesselingh & Alçiçek 2010), *Microtus* sp. **Acıgöl:** 3760 BP (Sulpizio et al. 2013, Athanassas et al. 2018), 2.5 Ma (Lebatard et al. submitted)	Toringian-early Biharian
Ungular unconformity		
Anastomosing fluvial	**Çameli-Bıçakçı**: *Sus strozzii, Mimomys pliocaenicus, Mimomys* gr. *M. tornensis, Pitymimomys pitymyoides, Borsodia* gr. *newtoni-arankoides, Kalymnomys* sp., *Clethrionomys kretzoii, Cricetus* sp., *Mesocricetus* aff. *primitivus, Cricetulus* aff. *migratorius, Pliospalax* sp., *Apodemus* cf. *flavicollis, A. atavus, Pliospalax* sp., *Beremendia* sp., Soricinae gen. et sp. indet. **Burdur Kocakır-1:** *Equus* sp., *Paracamelus* gigas, Cervidae gen. indet. (Alçiçek et al. 2013, Demirel et al. 2016, 2017). **Burdur Kocakır-2**: *Equus* cf. *altidens, Equus* sp., *Stephanorhinus* cf. *etruscus, Paracamelus gigas*, Bovidae indet, *Hippopotamus* sp., *Panthera* ex. gr. *gombagzoegensis, Canis etruscus* (Demirel et al. 2016, 2017). **Burdur Elmacık**: *Mammuthus meridionalis,* Elephantidae indet, *Equus stenonis/altidens, Equus* sp., *Stephanorhinus* cf. *etruscus, Gazellospira torticornis, Leptobos etruscus, Leptobos* sp., Bovidae indet. *Eucladoceros* sp., Cervidae indet., *Testudo* sp. (Alpagut et al. 2015). **Burdur Yassıgüme**: *Equus* sp., *Gazellospira torticornis, Leptobos* cf. e*truscus,* (Demirel & Mayda 2014). **Burdur Basin**: Pmag, 2.5 Ma (Özkaptan et al. 2018). **Burdur-Hasanpaşa:** *Mammuthus meridionalis, Gazella* sp. (MN17, Saraç 2003)	Latest Villanyian (latest MN17)
Lacustrine	**Çameli Basin:** *Melanopsis narzolina, Pseudamnicola kochi, P. margarita margarita, P. margarita nuda, Paludina, Lymnaea, Radix, Lithoglyphus* and *Pyrgula*, Ostracod: *Amplocypris marginata, Candona* sp., *C. sieberi nodosa, C.* exigua, *Darwiluna cylindrical, Eucypris* sp., and *Metacypris* sp. (Becker-Platen 1970), *Cyprideis pannonica, Candona parallela pannonica, Heterocypris salina, Ilyocypris* sp. *Eucypris* sp. (Darbaş 2017).	Late Pliocene

	Burdur Basin: Complete ostracod fauna (Tunoğlu & Bayhan 1996). **Baklan-Gelinören**: *Pseudomeriones tchaltaensis* (MN15, Wesselingh & Alçiçek 2010). **Eşen Basin:** *Adelina elegans, Lymnaea longiscatus, Paludina cibyratica, Unio* sp. (Spratt & Forbes 1847), *Fluminicola (Gilbia) lycia* (Oppenheim 1919), *Pisidium* sp., *Ilyocypris* cf. *expansa, Bulimus (Tylopoma)* cf. *avellana, Planorbidae* sp. (Colin 1962), *Cypridopsis, Ilyocypris, Limnocythere, Adelina, Fluminicola, Bulimus, Planorbis, Limnaea* (Becker-Platen 1970) *Bulimus (Tylopoma)* cf. *pilari, Corymbina* aff. *rhodensis* var. *istridica, Ancylocypris sinuosa, Miocyprideis janoscheki, Candona filona, Candona extensa, Pontocypris balcanica, Cyprideis* aff. *littoralis, Ilyocypris* cf. *iners, Candona ex* aff. *neglecta, Candona granulose, Ilyocpris* sp. *Hemicythere convexa, Candona albicans pannonica, Eucypris* sp., *Cyprideis heterostigma, Candona* aff. *balatonica, Hemicythere convexa, Candona* aff. *albicans, Candona albicans pannonica, Cyprinotus congener, Limnocythere* sp. (= *Limnocythere*), *Tyrenocythere* sp. (Becker-Platen 1970), *Acer* aff. *trilobatum, Acer angustilabum* (Şenel 1997b, c), *Candona (Candona) xanthica, Candona (Candona) metohica, Candona (Candona) cabrati, Cypridopsis* sp., *Ilyocypris bradyi, Candona (Caspiocypris*) sp. *Candona (Candona) bimucronata*, ?*Cypridopsis* sp., *Limnocythere* sp., *Candona (Candona)* cf. *cabrati, Ilyocypris bradyi, Candona (Metacandona*) cf. *dasherahi, Candona (Fabaeformiscandona*) cf. *krstici, Candona (Caspiocypris)* sp., *Candona (Pontoniella)* sp., *Zonocypris* cf. *membrane, Cyprideis torosa*	
Anastomosing fluvial	**Çameli-Ericek**: *Cricetulus* sp. *Apodemus* cf. *dominans, Orientalomys* cf. *similis, Mimomys occitanus, Muscardinus* sp. *Asoriculus* sp. *Rhagapodemus primaevus, Bythinia* indet., *Pseudamnicola* spec., *Hydrobia* s.l. sp. *Valvata* aff. *V. macrostoma, Galba* sp. *Vertigo* sp., *Gyraulus* sp. Cyprinidae pharyngeal, Cyprininae, *Capoeta* sp., *Capoeta* cf. *damascinaor* or *C.* cf. *sieboldi, Carassius, Leuciscinae,? Squalius sp., Tincinae, Tinca sp., Barbus sp.,* Cobitidae, Gobiidae, ?Palaeobatrachidae indet. Anura indet. Colubridae indet. (Serpentes), Colubridae indet. or Elapidae indet. (MN15, Van den Hoek Ostende et al. 2015a). **Eşen:** Cyprinodei *Onychodens* sp., Cyprinodei *Mitradens* sp., Cyprinodei *Tinca* sp. (Alçiçek 2007). **Baklan:** *Pseudomeriones tchaltaensis (*Wesselingh & Alçiçek 2010), **Burdur-Sultandere:** *Croizetoceros* cf. *romanus, Gazellospira* sp. (MN16, Mayda et al. 2017). **Burdur Basin**: 5.0-4.5 Ma (Özkaptan et al. 2018). **Muğla-Yatağan-Bozarmut:** Perissodactyla Equidae Hipparion, Rodentia Arvicolinae (MN14, Saraç 2003)	Late Ruscinian (late MN15)
Alluvial-fan floodplain	**Çameli-Elmalıyurt (Pırnaz):** *Hipparion* cf. (MN11-12, Saraç 2003, later determined by G. Saraç as *Hipparion* cf. *H. primigenium,* (MN11-12, Alçiçek et al. 2005, re-examined in this study and revised as *Hipparion* cf. *mediterraneum* MN11-12) **Eşen-Karamusalar:** *Palaeotragus rouneii* (MN11-12, Alçiçek 2007). The specimen of *Palaeotragus rouneii* re-examined with support of new findings of *Gazella* sp., *Hipparion* sp., Cervidae indet. and assigned to MN11-12 in this study. **Burdur-Kemer:** Giraffidae indet. (late Miocene, Price, 1989). **Denizli-Çal-Asarlık:** *Samotherium* sp., *Palaeotragus* sp., *Gazella* sp., *Palaeoreas* cf. *elegans, Microstonyx* sp., *Ancylotherium pentelici, Hipparion* sp., (mid-Turolian (MN12), Alçiçek et al. 2012) **Denizli-Mahmutgazi:** *Oioceros wegneri, Palaeoreas lindermayeri, Tragoportax amalthea, T. gaudryi, Gazella capricornis, Gazella gaudryi, Palaeotragus coelophrys, Samotherium boissieri, Microstonyx erymanthius, Dicoryphochoerus* sp, *Machairodus aphanistus Adcrocuta eximia,*	Early Turolian (MN 11-12)

	Protictitherium crassum, Ictitherium robustum, Ictitherium tauricum, Percrocuta eximia, Ceratotherium neumayri, Chilotherium schlosseri, Choerolophodon pentelici, Orycteropus sp., *Hippotherium* sp. (Sickenberg et al.1975, Pickord 2016, Geraads 2017). **Denizli-Beyağaç-Sazak:** *Hipparion matthewi, Ceratotherium neumayri, Gazella deperdita, Protoryx carolinae, Tragoportax almathea, Helladotherium duvernoyi, Adcrocuta eximia. (*Kaya 1993, Tuna 1999, Koufos et al. 2018). **Denizli-Beyağaç-Kozlar:** *Hipparion* sp., *Ceratotherium* sp. **Muğla-Özlüce**: *Dinocrocuta gigantea, Choerolophodon anatolicum, Hipparion* sp. (I), *Hipparion* sp. (II), *Ceratotherium neumayri, Chilotherium* cf. *kiliasi, Chilotherium* nov. sp., *Sporadotragus* nov. sp., *Skoufotragus* sp. *Microstonyx* sp., (early Turolian (MN11), Alpagut et al. 2014). **Muğla-Yatağan-Şerefköy 2 :** *Machairodus giganteus, Felis attica, Paramachairodus orientalis, Adcrocuta eximia, ?Ursavus* sp., *Parataxidea* cf. *maraghana, Pliohyrax graecus, Diceros neumayri, Dihoplus* sp., *Ancylotherium pentelicum, Cremohipparion* sp. type 1, *Cremohipparion* sp. type 2, "*Hipparion*" sp. type 1, "*Hipparion*" sp. type 2, *Hippotherium brachypus, Microstonyx major, Palaeotragus rouenii, Samotherium* sp., *Orycteropus gaudryi, Choerolophodon pentelici, Deinotherium* sp., *Gazella* cf. *G. capricornis, Palaeoryx pallasi*, *Sporadotragus parvidens*, *Skoufotragus* cf. *Sk. schlosseri*, *Urmiatherium rugosifrons*, ?*Sinotragus* sp. (Kaya et al. 2012, Kostopoulos et al. 2015). **Muğla-Salihpaşalar 1,2,3,4,5,6***:* (1) *Ictitherium robustum, Ictitherium hipparionum, Adcrocuta eximia, Hipparion mediterraneum, Hipparion matthewi, Dicerorhinus orientalis, Microstonyv* sp. *Palaeotravus rovenii, Protoryx carolinae, Gazella deperdita.* (2) *Ictitherium robustum, Ictitherium hipparionum, Adcrocuta eximia, Hipparion matthewi, Dicerorhinus orientalis, Ceratotherium neumayri, Palaeotravus rovenii, Palaeoryx pallasi, Protoryx carolinae, Gazella deperdita,* (3) *Hipparion* sp. (4) *Hipparion* sp. *(5) Ceratotherium neumayri,* (6) *Hipparion* sp., *Ceratotherium* sp. (Saraç 2003). **Muğla-Elekçi:** *Ictitherium* sp., *Hipparion matthewi, Gazella gaudryi, Gazella deperdita, Palaeoryx pallasi.* (Saraç 2003). **Muğla-Ulaş**: *Hipparion* sp., *Chilotherium samium,* (Saraç 2003). **Uşak-Kemiklitepe***: Lycyaena* sp., *Hyaenotherium wongii, Machairodus aphanistus, ?Indarctos* sp., *Hipparion mediterraneum, Hipparion matthewi, Hipparion* sp. (I), *Hipparion* sp. (II), *Ceratotherium neumayri, Dicerorhinus pikermiensis, Chilocotherium* aff. *persiae, Chilotherium ?*sp., *Hystrix primigenia, Pseudomeriones* sp., *Orycteropus gaudryi, Ancylotherium* cf. *pentelicum, Pliohyrax graecus, Choerolophodon pentelici, Palaeotragus rouenii, Samotherium major, Samotherium?* sp., *Protoryx parvidens, Criotherium argalioides, Palaeoreas* cf. *elegans, Gazella* sp, *Protoryx laticeps, ?Palaeoryx* sp., *?Oioceros wegner, Gazella* sp., Bovidae indet. (I), Bovidae indet. (II) (Şen 1994). **Uşak-Karabeyli :** *Hipparion* sp., *Struthio* sp., *Ictitherium viverrinum, Hipparion brachypus, Hipparion* sp. (II), *Paleotragus* sp., *Gazella capricornis, Protoryx* sp., *Palaeoryx pallasi*, *Hippopotamodon major, Samotherium boissieri, Choerolophodon pentelici* (Seyitoğlu et al. 2009). **Burdur Basin:** 4.77±0.25 to 4.07±0.20 Ma (Lefevre et al. 1983), 4.6±0.2 Ma (Price 1989). **Çameli Basin:** 6.9 Ma (Elitez et al. 2017), 6.52±0.33 to 4.59±0.57 (Paton 1992), 6.71±0.2 (Westaway et al. 2005).	
	No deposition, ca 7 Ma (late Burdigalian-late Tortonian)	

Reef Limestone (brackish-shallow marine)	**Acıpayam reef:** Gastropoda: *Turritella turris, Tenagodus* cf. *terebellus, Oligodia bicarinata*, *Phalium (Phalium) cypraeiformis*, *Melongena* cf. *cornuta*, *Conus (Conospirus*) *dujardini*, *Conus* (*Lithoconus*) *mercati*, Bivalvia: *Hyotissa hyotis, Codakia* cf. *Leonina, Ostrea lamellosa, Venus (Antigona) burdigalensis producta, Pecten subarcuatus styriacus, Lutraria* cf. *sanna, Pelecyora (Cordiopsis) islandicoides, Venus (Antigona) burdigalensis producta,* Ostracoda: *Aurila soummamensis, Neonesidea corpulenta, Xestoleberis glabrences, Hermanites* aff. *haidingeri minör, Cytherura* cf. *gibba, Cytheretta* aff. *ramosa sublaevis, Hemicyprideis rhanana, Krithe papillosa, Neomonoceratina helvetica*, *Neonesidea corpulenta, Krinta papillosa*, *Bairdia* s*abdeltoidea*, *Cytkerell vulgata*, *Paracypris polita*, *Hermanites* aff. *haidingeri minor*. Benthic foraminifera: *Miogypsina intermedia*, *Miogypsina* cf. *irregularis, Neoalveolina melo, Operculina complanata, Ammonia becarii, Quinqueloculina* sp., *Amphistegina* sp., *Elphidium* sp., Rotaliidae, Miliolidae. Scleractinian corals: *Heliastraea* cf. *mellahica*, *Stylophora* cf. *raristella*. *Tabellastraea* sp., *Favia* sp. Algae: *Lithophyllia* sp., *Lithothamnium* sp. *Melobesia sp.*	Late Burdigalian
Autochthonous and allochthonous basement units (Mesozoic-Miocene)		